

307.220

FORMERLY ACTA BOTANICA ACADEMIAE SCIENTIARUM HUNGARICAE

Vol.

Acta Botanica Hungarica

VOLUME 29, NUMBERS 1-4, 1983

MANAGING EDITOR

A. BORHIDI

EDITORIAL BOARD

**P. JAKUCS (Chairman), A. BORHIDI, G. FEKETE,
L. FRIDVALSZKY, T. HORTOBÁGYI, P. JUHÁSZ-NAGY,
I. MÁTHÉ, T. PÓCS, T. SIMON, B. ZÓLYOMI**



Akadémiai Kiadó, Budapest

ACTA BOT. HUNG. 29(1-4) 1-404 (1983) HU ISSN 0001-5350

ACTA BOTANICA

A QUARTERLY OF THE HUNGARIAN ACADEMY OF SCIENCES

Acta Botanica publishes original reports on botanical subjects in English, French, German, Spanish and Russian

Acta Botanica is published in yearly volumes of four issues by

AKADÉMIAI KIADÓ
Publishing House of the Hungarian Academy of Sciences
H-1054 Budapest, Alkotmány u. 21.

Manuscripts and editorial correspondence should be addressed to
Acta Botanica 1363 Budapest P.O. Box 24

Subscription information

Orders should be addressed to

KULTURA Foreign Trading Company
1389 Budapest P.O. Box 149

or to its representatives abroad

Acta Botanica is indexed in Current Contents

INSTRUCTIONS TO AUTHORS

Papers will be considered for publication in *Acta Botanica Hungarica* only if they have not previously been published or submitted for publication elsewhere. They may be written in English, French, German, Russian or Spanish. From Hungarian authors papers are also accepted in Hungarian.

Manuscripts should be sent to

Prof. Pál Jakucs
editor-in-chief

or to

Prof. Attila Borhidi
managing editor

Ecological Department,
Kossuth Lajos University,
H-4010 Debrecen

Botanical Institute of the
Hungarian Academy of Sciences
H-2163 Vácraót

Form of manuscript

Manuscripts should be typewritten in duplicate, double-spaced, 25 lines with 50 letters on each page. Articles should in general not exceed 25 typed pages tables and illustrations included. Acceptance depends on the opinion of one or more referees and the decision of the Editorial Board. Papers accepted for publication are subjected to editorial revision.

CONTENTS

Sándor Jávorka born 100 years ago (<i>B. Zólyomi</i>)	5
Studies in Rondeletieae (Rubiaceae), IV. A new genus: <i>Javorkaea</i> (<i>A. Borhidi, Magda Járαι-Komlódi</i>)	13
Studies in Rondeletieae (Rubiaceae), V. Los limites del género <i>Suberanthus</i> (<i>A. Borhidi, Mayra Fernandez Zequeira</i>)	29
Studies in Rondeletieae (Rubiaceae), VI. Estudio taxonómico de la <i>Rondeletia odorata</i> Jacq. (<i>Mayra Fernandez Zequeira, P. Herrera Oliver</i>)	35
Studies in Rondeletieae (Rubiaceae), VII. The significance of leaf epidermis for taxonomy in <i>Neomazaea</i> sensu lato (<i>M. A. Vales</i>)	43
Chromosomal aberrations and chlorophyll mutations induced by some pesticides in barley (<i>T. Pusztai</i>)	55
Chromosomal and isoenzyme variability in callus tissue cultures of albino mutant of <i>Nicotiana sylvestris</i> (<i>L. Szilágyi, A. H. Nagy</i>)	67
Morfología del polen de las especies cubanas de Gymnospermas (<i>L. Stuchlick, Milagros Moncada</i>)	75
A compendium of the morphology of <i>Phytophthora cinnamomi</i> Rands from Australia (<i>L. Gerretson-Cornell</i>)	91
Observations on the Hyphomycetes inhabiting forest litter of Hungary (<i>J. Gönczöl, Á. Révay</i>)	107
Disjunct Hepaticae in tropical America and Africa (<i>S. R. Gradstein, T. Pócs, J. Váňa</i>)	127
The rediscovery of <i>Loiseaubryum ephemeroides</i> Bizot (Musc: Funariaceae) in Nigeria (<i>R. Ochyra</i>)	173
New names and new species in the flora of Cuba and Antilles, III (<i>A. Borhidi</i>)	181
Xylotomic examination of some Venezuelan <i>Capparis</i> species, III (<i>K. Babos, I. R. Bermudez, L. J. C. Cumana</i>)	217
Contribución al estudio anatómico del xilema de la familia Simarubaceae en Cuba, I. <i>Alvaradoa</i> Liebm. y <i>Simaruba</i> Aubl. (<i>M. A. Vales, Cándida Martinez</i>)	231
Developmental anatomy of the <i>Armeniaca vulgaris</i> Lam. (Rosaceae) (<i>J. Szujkó-Lacza</i>)	241
Screening of some common Indian trees for leaf protein (<i>A. K. Singh</i>)	281
The effect of increasing nitrogen doses upon dry matter production, transpiration and water utilization of maize plants (<i>S. Szlovák</i>)	293
Study of the phytoproduction of Reed Canary-grass sown on solonetz meadow-soil type (<i>A. Kovács</i>)	307

15-N dynamic in grassland communities, I. Investigation of the plant subsystem in a sandy grassland (<i>E. N. Molnár, J. N. Nosek, G. Bakonyi</i>)	327
Plant communities of Cuba, I. Fresh and salt water, swamp and coastal vegetation (<i>A. Borhidi, O. Muñiz, E. Del Risco</i>)	337
The local complex of phytocenoses and the vegetation landscape — fundamental units of the spatial organization of the vegetation above the phytocoenose level (<i>J. Solon</i>)	377
Book reviews	385

CONTENTS

Sándor Jávorka born 100 years ago (<i>B. Zólyomi</i>)	5
Studies in Rondeletieae (Rubiaceae), IV. A new genus: <i>Javorkaea</i> (<i>A. Borhidi, Magda Járαι-Komlódi</i>)	13
Studies in Rondeletieae (Rubiaceae), V. Los limites del género <i>Suberanthus</i> (<i>A. Borhidi, Mayra Fernandez Zequeira</i>)	29
Studies in Rondeletieae (Rubiaceae), VI. Estudio taxonómico de la <i>Rondeletia odorata</i> Jacq. (<i>Mayra Fernandez Zequeira, P. Herrera Oliver</i>)	35
Studies in Rondeletieae (Rubiaceae), VII. The significance of leaf epidermis for taxonomy in <i>Neomazaea</i> sensu lato (<i>M. A. Vales</i>)	43
Chromosomal aberrations and chlorophyll mutations induced by some pesticides in barley (<i>T. Pusztai</i>)	55
Chromosomal and isoenzyme variability in callus tissue cultures of albino mutant of <i>Nicotiana sylvestris</i> (<i>L. Szilágyi, A. H. Nagy</i>)	67
Morfología del polen de las especies cubanas de Gymnospermas (<i>L. Stuchlick, Milagros Moncada</i>)	75
A compendium of the morphology of <i>Phytophthora cinnamomi</i> Rands from Australia (<i>L. Gerretson-Cornell</i>)	91
Observations on the Hyphomycetes inhabiting forest litter of Hungary (<i>J. Gönczöl, Á. Révay</i>)	107
Disjunct Hepaticae in tropical America and Africa (<i>S. R. Gradstein, T. Pócs, J. Váňa</i>)	127
The rediscovery of <i>Loiseaubryum ephemeroides</i> Bizot (Musci: Funariaceae) in Nigeria (<i>R. Ochyra</i>)	173
New names and new species in the flora of Cuba and Antilles, III (<i>A. Borhidi</i>)	181
Xylotomic examination of some Venezuelan <i>Capparis</i> species, III (<i>K. Babos, I. R. Bermudez, L. J. C. Cumana</i>)	217
Contribución al estudio anatómico del xilema de la familia Simarubaceae en Cuba, I. <i>Alvaradoa</i> Liebm. y <i>Simaruba</i> Aubl. (<i>M. A. Vales, Cándida Martinez</i>)	231
Developmental anatomy of the <i>Armeniaca vulgaris</i> Lam. (Rosaceae) (<i>J. Szujkó-Lacza</i>)	241
Screening of some common Indian trees for leaf protein (<i>A. K. Singh</i>)	281
The effect of increasing nitrogen doses upon dry matter production, transpiration and water utilization of maize plants (<i>S. Szlovák</i>)	293
Study of the phytoproduction of Reed Canary-grass sown on solonetz meadow-soil type (<i>A. Kovács</i>)	307

15-N dynamic in grassland communities, I. Investigation of the plant subsystem in a sandy grassland (<i>E. N. Molnár, J. N. Nosek, G. Bakonyi</i>)	327
Plant communities of Cuba, I. Fresh and salt water, swamp and coastal vegetation (<i>A. Borhidi, O. Muñiz, E. Del Risco</i>)	337
The local complex of phytocenoses and the vegetation landscape — fundamental units of the spatial organization of the vegetation above the phytocenose level (<i>J. Solon</i>)	377
Book reviews	385

307. 220

ACTA BOTANICA HUNGARICA

EDITORIAL BOARD

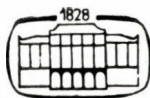
P. JAKUCS, Chairman

A. BORHIDI, G. FEKETE, L. FRIDVALSZKY,
T. HORTOBÁGYI, P. JUHÁSZ-NAGY,
I. MÁTHÉ, T. PÓCS, T. SIMON, B. ZÓLYOMI

MANAGING EDITOR

A. BORHIDI

VOLUME 29



AKADÉMIAI KIADÓ, BUDAPEST

1983

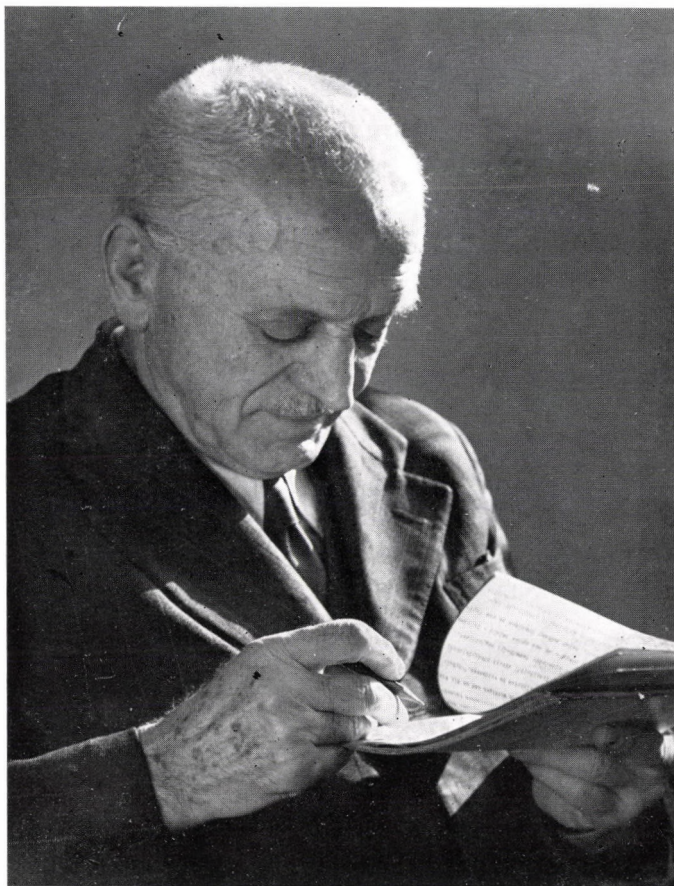
ACTA BOT HUNG.

EDITORIAL NOTE

The name of *Acta Botanica Academiae Scientiarum Hungaricae* has been abbreviated to *Acta Botanica Hungarica*. *Acta Botanica Hungarica* is a journal of the Hungarian Academy of Sciences. The change does not affect the status and the editorial policy of the journal.

SÁNDOR JÁVORKA
BORN 100 YEARS AGO

B. ZÓLYOMI



Hungarian botanists pay tribute to the memory of Sándor JÁVORKA on occasion of the centenary of his birth. His work was an important milestone in research exploring the flora of South-Eastern Europe and of the Carpathian Basin. His critical studies represented a synthesis of the intensive exploratory work of the nineteenth and early twentieth centuries and at the same time made way for a more detailed research of the flora.

Sándor JÁVORKA was born in Hegybánya, in the former county Hont, on March 12th, 1883. His father, a village smith was a descendant of Ádám

JÁVORKA who had fought in the insurrection against the HABSBURGS led by Prince RÁKÓCZI. His mother was a simple village woman, who, after her husband's early death, was left alone with her six children. She could not support his son Sándor, who attended a grammar-school at Selmechánya and had to give lessons and do odd jobs from his early childhood. Besides, he also helped her mother. He began his university studies at the PéterPÁZMÁNYs University, Budapest living under similarly poor circumstances but graduated with a doctor's degree.

In 1905, following his early inclinations, he began to work in the Herbarium of the Hungarian National Museum and later, when this section of the museum had become independent, in that of the Museum of Natural Sciences. He stayed there till the end of the active period of his life and between 1934–1940 he was a director of the Herbarium. Having retired, he worked there almost every day for another twenty years. It was his second home until his death. In appreciation of his scientific work he was elected corresponding Member of the Hungarian Academy of Sciences in 1936, and became Full Member in 1943. He was awarded several high honours and in 1952 he became a KOSSUTH Prize laureate. He died on September 28th, 1961.

He began to deal with botany, collect and identify plants at 15, while still at grammar-school, mainly in the environs of Selmechánya and Hegybánya and Sitnya (1898–). CSEREI's schematic plant identification handbook was of great help to him, but he was annoyed when he could not identify a plant because the book included only some species of the flora. He decided at this age to write a much better and much more complete book. He first embarked on his research trip as a university student in the environs of Budapest (Dorog, Visegrád). His first floristic publications also appeared during this period (1903–1904), and he started his researches in the South-Carpathians of Transylvania. He wandered in the Alps of the Godjan, Surjan and the Retyezát (1902 and 1904), where he stayed in the cottages of alpine herdsmen.

He already worked in the Museum when his university doctor's dissertation with the title "Species Hungaricae generis *Onosma*" appeared in the Annales of the Museum in 1906. His unerring taxonomic judgement is shown by the fact that the English translation of this dissertation was published in the Journal of Botany twenty years later. The revision of the related European species of *Linum flavum* L. (1910) in which, among others, the place of the endemic *Linum dolomiticum* Borb. was cleared up besides that of *L. elegans* Sprun. the native of Dalmatia and Greece, can be mentioned from among his several studies.

He published a total number of some 220 scientific, educational and popular works, eleven of them were books some of which had several editions.

The most outstanding result of Sándor JÁVORKA's research of almost 20 years on the site and in the herbarium and library of the Museum is the book *Flora Hungarica* (1924–1925) dealing with the flora of the pre-world-War-I Hungary. Although it had been meant to be an identification book, the scope of this critical synthetizing work reaches far beyond that of similar books as regards its contents. In it he gave a true picture of the rich flora of the Carpathians and their basin, the Pannonicum.

Let me now make a little detour. I think it is not an accident but just characteristic that in Sándor JÁVORKA's flora work of 1925 the critical, polymorph genera were elaborated not only by specialized taxonomic botanists. Thus, for example, the species of the *Thymus* (thyme) genus of the Carpathian Basin were worked out by Károly LYKA, an art historian and those of the *Mentha* genus by Robert TRAUTMAN, an architect. According to the investigation methods of that time of microsystematics, the sophisticated sense of form was decisive, and mostly characteristic of those dealing with arts. Very finely distinguished outer formal features, ways of furcate branching, characters and forms of leaf nervation, length and width proportions are included in their taxonomic keys. It is a typology building on the outer formal features.

With a further development of taxonomy, genetic taxonomy relying on the results of inheritance has come into prominence in recent decades. Within a genus or species each, taxonomy is concerned with the results of the chromosome and gene investigations, and population research is considered to be an indispensable control. Thus the unity of form and function finds expression. But for all these, well-equipped laboratories and experimental investigations are needed. The Museum either tries to become modern or has to cooperate with research institutes.

Since no illustrations were included in the book mentioned, the work *Iconographia Florae Hungaricae* (1929–1934) by Sándor JÁVORKA and Vera CSAPODY served as a supplement to it. From the point of view of the truthfulness of the more than 4000 plant pictures and the fidelity of details, this is one of the most valuable works of the European botanical literature. It was published with a preface in eight languages (including Slovakian, Romanian, Croatian and Italian). These works gave an impulse to further exploring activities. "A magyar növényvilág kézikönyve" (Handbook of the Hungarian Plant Kingdom) vols I–II (1951) by S. JÁVORKA and R. Soó was published by the Hungarian botanists' association. Other works which reflect the influence of the *Iconographia* include J. DOSTAL, *Kvetena ČSR* (1950), T. SAVULESCU and E. J. NYÁRÁDY, with the general editorship of E. POP: *Flora Reipublicae Popularis Romaniae I–XII* (1952–1972) and the great Soviet flora work, the *Flora SSSR I–XXX* (1934–1964). Nevertheless, no work comparable to the *Iconographia* has been published, which would have shown

the Illyrian and Mediterranean flora together with the species of the Carpathians, Pannonia and Croatia. That is why a decade and a half after Sándor JÁVORKA's death a new, partly revised second edition of the illustrated atlas was published, entitled, "Iconographia florae partis austro-orientalis Europae Centralis" (Akadémiai Kiadó, Budapest, 1975).

In a historical synthesis JÁVORKA reviewed, after publication of the KITAIBEL-Herbarium (1926–1936), the life work of his great predecessor, Pál KITAIBEL, the "Hungarian LINNE".

The influence of Sándor JÁVORKA, through his works and personal activity and connections, on the development of the Hungarian agricultural scientific research and practice is hard to estimate. He was one of the joint authors of the two volume handbook, "Magyar gyógynövények kézikönyve" (Hungarian Medicinal Plants) published by the Ministry of Agriculture in 1948. It was his outstanding merit that with F. ERDEI as joint general editor in 1959 they started the series "Magyarország kultúrflórája" (Crop Flora of Hungary). More than 100 contributors participated in this venture of the Department of Agricultural Sciences of the Hungarian Academy of Sciences. The series is still being continued and the number of the contributors has grown to more than 200. At present the general editor of the series is I. MÁTHÉ. JÁVORKA's posthumous work, the *Castanea* was published in this series in 1969.

Sándor JÁVORKA's pioneer activity in Hungarian nature protection deserves particular attention. When nature protection was included in title 6 of the so-called "Second Forest Act" (1935: Article IV) and the establishment of the Hungarian Council for Nature Protection was decreed, Sándor JÁVORKA offered a proposal elaborated in detail to protect and reserve 16 areas of high priority from the point of view of botany (the cenological reasons were given by the Author of this commemoration).

A list of the plant species to be protected was also drawn up in 1935–36. Unfortunately, its realization was protracted, in many cases, in fact it was cancelled. (In the same way the proposal made for the irreplaceable natural values of Békő in the Bükk Mountain, which had advised as a quarry supplying the cement-works to be placed on the neighbouring "Ördög"-Mountain, however, today the new plant is nearer to it, and the quarry has remained there.) In order to realize the proposal Sándor JÁVORKA together with those competent to deal with it, i.e. with Miksa FÖLDVÁRY, the managing president at the time of the Council for Nature Protection (1940–1944), and with Gábor MOLCSÁNYI and others (1948–1953) inspected the sites many times. (Such, for example, the *Callunetum* near Uzsa, the *Taxus* woods in the vicinity of Szentgál, the Alcsut Park, the dolomite vegetation of the Sas Mountain and Kis-Szénás, the *Crambe tataria*, protection of the habitat of the *Adonis vologensis*, etc.)

From the beginning Sándor JÁVORKA believed in establishing close connections between Hungarian botany and forestry. I can refer to Lajos FEKETE and Tibor BLATTNY's work, entitled "Az erdészeti jelentőségű fák és cserjék elterjedése . . . (Distribution of the trees and shrubs of importance to forestry) (Selmechánya, 1913–1914), in which the *Ericaceae* were elaborated by Sándor JÁVORKA. Dániel FEHÉR and Pál MAGYAR also represented a forest-botanical direction known and accepted internationally, too. Károly KAÁN's work (1931) is of fundamental importance in the history of Hungarian nature protection. JÁVORKA's role, in the enforcement of the 1935 Act, has already been mentioned, later his close connection with other forest botanists will also be described.

In the publication entitled "Guide to choosing the tree species to be grown in forest management" V. AJTAY (1950) ("Tájékoztató az erdőgazdaságban tenyésztenődő fafajok megválasztásához") he gave a description of the soil indicating plants while the figures were drawn by Vera CSAPODY. His articles intended for practice deal with the connections between forestry and plant geography.

In the 1950ies forest typology realized its purpose both nationally and internationally. The biological-ecological view seemed to play a due part in forest-cultivation. One can refer to the four-volumes, compiled by I. DANSZKY, entitled "Magyarország erdőgazdasági tájainak erdőfelújítási, erdőtelepítési irányelvei és eljárásai" (Guiding principles and ways of forest renewal and plantation of the forest management areas of Hungary; Országos Erdészeti Főigazgatóság, 1963), furthermore, to the series, entitled "Vegetation ungarischer Landschaften", edited by Bálint ZÓLYOMI, published between 1957–1977 by the Publishing House of the Hungarian Academy of Sciences.

Unfortunately, in the latest decades a much more narrowed economical, technical, technological, forest-industrial viewpoints and practice have been prevailed in the forest management. The ecologist-forest-typologist seems to be ousted from forest cultivation and can only maintain secondary role in the field of forestry environment protection.

However much Sándor Jávorka worked in the Herbarium of the Museum, he regarded inevitable the observations in nature and the participation in the open field researches. With the possibilities provided by the Museum he methodically roved and explored the whole range of the Carpathians, mainly the areas which had previously been neglected. As a young man he made several trips to the North Carpathians, the mountains and valleys of the North-Eastern, and South Carpathians to the Lower Danube, the Kazan Straits (all these meant 246 days of field work and a round 4800 herbarium specimens). Of the rich results of these journeys let us only mention two new Carpathian endemism, *Pulmonaria Filarszkyana* Jáv. from the mountain pine region of the Máramaros Alps (1916) and the *Draba Simonkaiana* Jáv. from the granite rocks of the Pareng and Retyczát (1910). He also

botanized in the Pannonian flora region, mainly in the environs of Budapest, in the Buda, Pilis and Visegrád mountains and in the lowland of Pest (around 200 days and 2100 plants).

The following years were devoted to synthesis, which, however, proved the need for further exploring work. In this, too, JÁVORKA took an active part. Even as an old man he methodically collected and investigated plants on field trips in the Pannonian flora region, most extensively in the environs of Budapest, in the Bakony Mountains and around Lake Balaton, furthermore in the Bükk Mountains and mainly, filling a gap with it, in Transdanubia (approx. 1360 days and 11 000 plants). His work "Plant Distribution Limits in Transdanubia" (Pflanzenareale in Transdanubien in Ungarn), his inaugural speech at the Academy in 1937, published in 1940, threw new light on the plant geographic judgement of the region and opened the way for further investigations. Special attention was paid to the species of hybridogen origin of the genus *Sorbus* (1926). The new data resulting from these trips were published in the above-mentioned handbook on the Hungarian Plant Kingdom.

At around the age of sixty he resumed his botanic trips in the Carpathians, mainly in Carpathian Ukraine, the Székely-land and in the Kelemen Alps (1939–1943, 80 days, 1600 plants). Following the Hungarian traditions of Balkan research, he took part in an expedition to Albania in 1918, on behalf of the Hungarian Academy of Sciences. Based on his own collections as well as on those of Béla J. KÜMMERLE and József ANDRASOVSKY, he described a whole series of new species and other taxa. The exploration of the serpentine flora to be found there was his particular merit. The following species may be mentioned, selected at random: *Ranunculus degeni* Kümm. et Jáv., *Sanguisorba albanica* Andras. et Jáv., *Ligustrum albanicum* Jáv., *Peucedanum serpentini* Andras. et Jáv., *Gentiana nopcsae* Jáv., *Lunaria telekiana* Jáv., *Erysimum korabense* Kümm. et Jáv., *Senecio korabensis* Kümm. et Jáv., *Cerastium hekuravense* Jáv., *Polygonum albanicum* Jáv. (Bot. Közlem. 19: 1920–1921). He was again in Albania in 1955, together with J. UJHELYI, but the material they collected has only partly been processed. His research work of 1929 in Bulgaria strengthened his earlier relations with Bulgarian botanists and enriched his knowledge of the Bulgarian flora. Of the new taxa the *Oxytropis uromovii* Jáv. endemic in the Pirin Mountains can be mentioned. Besides the Carpathians, he turned his attention also to the mediterranean and submediterranean vegetation of the Adriatic coast. Apart from the Croatian and Dalmatian coasts he also went to Italy on a study trip and travelled in Austria and Switzerland.

At the 8th International Congress of Botany held in 1954 he was one of the delegates of the Hungarian Academy of Sciences. In 1957 he gave a survey of Hungarian botanic researches at the Federal Botanic Congress held in Lenin-

grad. He maintained a continuous professional and friendly connection with researchers of the neighbouring countries especially with those of Czechoslovakia. He was on friendly terms especially with Jan FUTAK. He corresponded with the directors of the botanic museums of Petrograd, Leningrad and Tbilisi from 1910. In spite of the severe Hungarian censorship, he kept up a friendly and professional correspondence with Boris FEDCHENKO and Vladimir KOMAROV, director of the Botanic Museum of Leningrad and later the President of the Soviet Academy of Sciences.

Although Sándor JÁVORKA did not choose teaching as a profession, he influenced several generations of Hungarian youths among others, through the medium of his small identification handbook on the Hungarian flora (1926 and 1937) and several editions of "Növényhatározó" (Plant Identification Book) (edited by T. HORTOBÁGYI 1952, 1962) compiled for university and college students. Although he was granted the honorary title of university professor at Szeged University in 1939, he never in fact gave courses. Nevertheless, many people regarded themselves as his students from among those who met him in the Museum but mainly those who participated in some form in his field work. He was an advocate of the confrontation of different opinions. In a sense he was a late representative of the classic peripatetic school (like THEOPHRASTOS, the "Father of Botany"). He often said that observation or demonstration in Nature is exactly as important as work in the herbarium. He often took along companions on his tours, who were honoured to join him. In the diaries of his trips he carefully recorded the names of those who accompanied him. It was VERA CSAPODY, who took part in most of his collecting tours, while his faithful companion, Béla LÁNYI organized the journeys. The present author accompanied him (on more than hundred occasions) mainly on his trips in Transdanubia. Of the generation of now middle-aged botanists, there is hardly anyone who had not had the opportunity to botanize together with Sándor JÁVORKA or to make use of his works.

A thorough knowledge of botany is one of the preconditions of phytocenological work. JÁVORKA's life work, handbooks and identification books opened the way for development of the plant cenological school started by Rezső Soó in Debrecen.

JÁVORKA believed that his vocation did not end at the scientific exploration of the plant kingdom but he also wanted this to become a popular asset. Therefore, he was a constant author of the columns of the popular magazines. More than a hundred thousand copies have been sold of the five Hungarian and one Slovak editions of "Erdő-mező virágai" (Flowers of the Forests and Fields) (1950–1972) he wrote together with V. CSAPODY. His book "Kerti virágaink" (Our Garden Flowers) is another example of his contributions to popular science. The book "Közép-európai dísznövények színes atlasza" (Coloured Atlas of the Central European Ornamentals Plants) written together with

Vera CSAPODY was ready for press immediately before his death and was published in 1962. Otherwise, a complete bibliography of Sándor Jávorka's life-work, a list of his tours and compilation on taxa dedicated to him or described by him can be found in *Annales Historico-Naturales Musei Nationalis Hungarici* (1962: 726, vol. 54.)

Sándor JÁVORKA's life cannot be sized up only through the objective investigation means used in history of science. His entire personality must be called attention to.

He was not only a great man, an outstanding personality of a period of history of science but a just man, a warm-hearted humanist as well. A quiet, modest person who was not self-conceited, disliked formalities, and ostentation. He was uncommunicative but friendly. He liked his colleagues and respected all those who were earnest in their desire for progress and knowledge. He esteemed his Fellow-men by their human values and works done. He especially liked and helped young people eager to learn. Anyone could turn to him with a professional question which strove to give a thorough, precise answer altruistically and patiently. He performed the tasks he was entrusted with or taken voluntarily upon himself exactly, conscientiously and with constant persistence. He disliked superficiality and carelessness but only mildly spoke out against them. He always condemned injustice.

He loved Nature very much, it was a vital element for him. He liked Life and its beauties, the products of science and art. Even to the last moments he paid attention to the events of the world around him. He was a wise man at the same time. With his observing eyes and mind he realized early that everything is moved by the laws and regularities of Nature and Society. Already in his early youth, he became aware of the reality of the material world, thus that of the human life. He realized and acknowledged that Death is the necessary dialectic opposite of Life. That is why he was never afraid of Death, only of a long-lasting illness, the defencelessness.

He considered work to be the main point in human life, work, scientific work, which serves the progress of people, of all mankind. He gave a good example of this with all his life.

STUDIES IN RONDELETIEAE (RUBIACEAE), IV

A NEW GENUS: JAVORKAEA

A. BORHIDI and MAGDA JÁRAI-KOMLÓDI

BOTANICAL RESEARCH INSTITUTE OF THE HUNGARIAN ACADEMY OF SCIENCES,
VÁCRÁTÓT, HUNGARY
PLANT SYSTEMATICS AND ECOLOGICAL DEPARTMENT OF THE EÖTVÖS LORÁND UNIVERSITY,
BUDAPEST, HUNGARY

(Received 1. January 1983)

A new monotypic genus from Honduras is separated from *Rondeletia* L. under the name *Javorkaea* based on the species *Rondeletia hondurensis* Donn.-Smith. Upon a comparative morphological and a thorough pollen anatomical study of this species in relation to the genera *Rondeletia* L. *Rogiera* Planch. and *Arachnothryx* Planch. its generic characteristics are discussed. The new genus is dedicated to the memory of the great Hungarian botanist, Sándor JÁVORKA to the centenary of his birth.

Introduction

As it was pointed out (BORHIDI and FERNANDEZ 1982: 309) the original concept of *Rondeletia* L. has been largely widened by DE CANDOLLE (Prodr. 4: 406, 1830) and BENTHAM (Pl. Hartw. 1841). Based upon a comparative morphological examination, BORHIDI and FERNANDEZ (1982a and b) determined the chief generic characteristics and Magda JÁRAI-KOMLÓDI studied (ined.) the pollen morphological features of *Rondeletia* L. based on *Rondeletia americana*. Comparing these characteristics with those of other groups of *Rondeletia*, it turned out, that a close correlation can be found between the different form of corolla-throat, the structures of placenta, form and pubescence of the ovary disc and the exine pattern and form of pollen grains. In consequence of these recognized correlations the mentioned authors separated as independent genera the monotypic Cuban *Roigella* and the Cuban-Hispaniolan polytypic *Suberanthus* (BORHIDI and FERNANDEZ 1982a and b), further resurrected the Central American *Rogiera* Planch. and contributed to the revalidation of the neotropical continental genus *Arachnothryx* Planch. (BORHIDI 1983) resurrected earlier by STEYERMARK (1967).

Rondeletia hondurensis was described by DONNEL-SMITH in the Botanical Gazette 27: 335 (1899). The type specimen is collected in Honduras, Santa Barbara, Río Chamelecón at an altitude of 300 meters. We had not opportunity to study this type specimen, but a very good collection made by HJALMARSSON in Honduras 1852, and classified by STANDLEY as *R. hondurensis*; specimens from the Riksmuseum of Stockholm.

Rondeletia hondurensis was first separated within the genus *Rondeletia*, as its monotypic section: Sectio *Hondurenses* by STANDLEY in the North American Flora 32A: 62 (1918). According to his description, the chief characteristics of the section *Hondurenses* are the following: "Leaves large, thin, loosely white-tomentose beneath. Stipules large, thin, erect. Inflorescence terminal, cymose-corymbose, many flowered, the flowers 5-parted, bracts large, calyx lobes large, narrow; corolla very large, sericeous outside, the throat naked."

Description of the genus *Javorkaea*

Based on our studies, *Rondeletia hondurensis* Donn.-Smith differs from *Rondeletia* L. and from the other related genera at generic level.

It is a shrub with stout, terete, densely white or fulvous pilose-sericeous branches. Stipules 7–12 mm long, persistent, the lower part connate into a 4–7 mm long ochrea-like ring, the upper part free with 1–3 cuspidate lobes. Leaves opposite, the petioles 2–8 mm long, the blades ovate, elliptic, oblong-elliptic or obovate oblong, 8–16 cm long, 3–5 cm wide, acute at the base, rather long acuminate to attenuate at the apex, thin, dark green and short pilose above, densely white arachnoid-tomentose beneath, sericeous along the veins, the costa slender, prominent, lateral veins slender, 6–8 on each side, subarcuate, ascending at an acute angle. Inflorescence is terminal, racemous-cymose, composed by 2–3 leafy whorles and a head-like terminal, many flowered cyme. Flowers sessile, bracts lanceolate, about 1.5 cm long, sericeous-villous, like hypanthium. Calyx 14–17 mm long, tube obovoid, 5–8 mm long, twice as long as the hypanthium, naked within; lobes 5–7 unequal, 7–10 mm long, one of them twice as broad as the others and longer, linear-lanceolate, cuspidate, villous, with a prominent dorsal costa. Corolla densely villous outside, the tube pubescent within near the base, 2–2.5 cm long, the throat naked; lobes 5, slightly unequal, 1–1.5 cm long, obovate, narrowed at the base, arachnoid-tomentose outside and densely bearded on the upper surface at the base. Anthers sessile, adnate to the throat, inserted, oblong-elliptic, 3 mm long. Pollen grains prolate-sphaeroidal, punctitegillate, 4-colporate, with a peculiar structure (see detailed description at the pages 17–27). Style short exerted, naked below, granulated above, clavate at the end; stigma bilobate, lobes triangular-semiorbicular, conduplicate. Ovary disc annular, entire, ascendent, thin, not lobed, essentially glabrous. Ovary elliptic to oblong, 2-valvate. Placenta oblong-elliptic, thin, plate, with a punctiform insertion to the upper part of the septum, slightly concave, pointed, not sulcate. Capsule oblong, loculicide with numerous wingless seeds.

It differs from both *Rondeletia*, *Rogiera* and *Arachnothryx* in having a broad, connate stipular ring with 1–3-lobed stipules, a 2–3-storied raceme-like terminal-cymose inflorescence, an 5–7-parted zygomorphic calyx, with long tube above the hypanthium, the large corolla with bearded lobes at the base, the granulated style and the head-like conduplicate stigma and the 4-colporate, punctitegillate pollen grains.

Furthermore it differs

- from *Rondeletia* L. in having terminal, racemose-cymose inflorescence, open corolla throat without callosity and naked ovary disc;
- from *Rogiera* Planch. in having naked corolla-throat and oblong ovary and capsule;

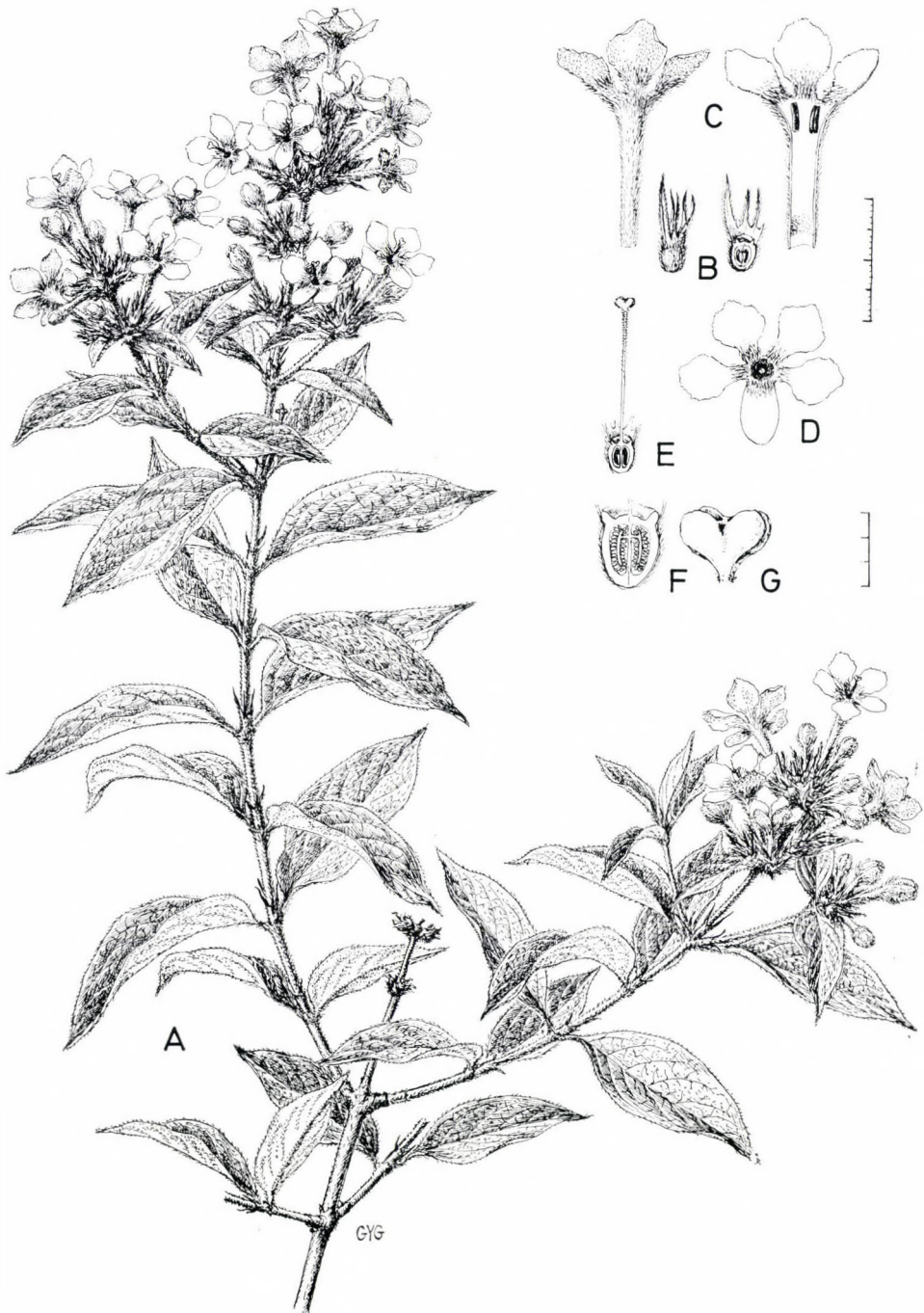


Fig. 1. *Javorkaea hondurensis* (Donn.-Smith) Borhidi et J. Komlódi. A: general habit; B: Calyx from outside and in longitudinal section; C: Corolla from outside and in longitudinal section; D: Corolla lobes and throat; E: Ovary and style; F: Ovary in longitudinal section with placentation; G: Stigma of style (original, drawn by Mrs. Gizella GYURKÓ)

- from *Arachnothryx* Planch. in having 5–6 parted flowers, corolla tube villous outside and an entire, not lobulate ovary disc;
- from *Roigella* Borhidi and Fernandez in having open corolla throat, loculicide capsule and thin, not sulcate placenta;
- from *Suberanthus* Borhidi and Fernandez in having 5–6-parted flowers, loculicide capsule, central placentation, and wingless seeds.

All these differences support the separation of *Rondeletia hondurensis* as a new monotypic genus, named *Javorkaea*.

***Javorkaea* Borhidi et J. Komlódi genus novum Rubiacearum**

Syn.: *Rondeletia* L. sect. *Hondurenses* Standl. N. Amer. Fl. 32: 62 (1918)

Frutices Hondurenses; rami teretes, ascendentes, dense albo- vel fulvosericiei. *Stipulae* ochreiformiter longe connatae, superne 1–3-lobatae, in dentes subulatae terminatae. *Folia* opposita, pergameae, oblongo-elliptica, antice acuminata, supra viridia, subtus arachnoideo-tomentosa. *Inflorescentiae* terminales cymoso-racemosae, ex verticillis foliosis 1–2, atque cymis capituliformibus terminalibus compositae. *Flores* sessiles, bracteatae, bracteae lanceolatae, magnae, villosae. *Calyx* bilateralis, tubus hypanthio duplo longior, lobi 5–7, valde inaequales, lanceolatae usque lineares, subulatae, corolla magna 2–3 cm longa, tubus 2–2,5 longus, extus villosus, intus basi puberulus, faux glaber, sine callositatibus, lobi 5, obovati extus arachnoideo-tomentosi, intus basi dense barbati, ceterum glabri. *Antherae* 5, sessiles, ellipticae, in fauce corollae affixae. *Grana pollinica* prolato-sphaeroidea, punctato-tegillata, 4-colporata. *Stylus* exsertus, superne granulatus, apice clavatus, stigma 2-lobata, semiorbicularia, longitudinaliter plicato-conduplicata. *Ovarii* discus integer, anilliformis, tenuis, adscendens, glaber. *Ovarium* ellipticum vel oblongum, 2-locularis, placenta oblongo-elliptica, tenuis, leviter concava, in septum supra medio punctiformiter introducta, leviter punctata, non sulcata; ovula numerosa, semina exalata.

Holotypus generis: Honduras; Dpt. Gracias. Leg.: HJALMARSSON 1852 (S!); det. P. C. STANDLEY as *Rondeletia hondurensis* Donn.-Smith. Isotypus: S!

Typus generis: ***Javorkaea hondurensis*** (Donn.-Smith) Borhidi et J. Komlódi **comb. nova.** — Basionymon: *Rondeletia hondurensis* Donn.-Smith Bot. Gaz. 27: 335 (1899).

Hoc genus in honorem dr-is et academici Alexander JÁVORKA, botanici et phytotaxonomici excellentissimi Hungarici, exploratoris florum Carpatho-Pannonicae atque Balcanicae notabilissimi, in centenario nativitatís dedicavimus.

Pollen Morphology of *Javorkaea hondurensis*

Pollen so far investigated in the Rubiaceae seems to be rather diverse (ERDTMAN 1952, 1963; VERDCOURT 1958; BREMEKAMP 1966; AIELLO 1979; BORHIDI, JÁRAI-KOMLÓDI, MONCADA 1980). This morphological diversification appears both in the structure (shape, size, sporoderm

stratification, NPC system of apertures) and in the sculpture (sexine patterns) of the pollen grains. Thus, this large family being rich in taxa (nearly 6000 species) and very heterogeneous from palynological point of view, needs further study.

Material and methods

Pollen was collected from herbarium type-specimen (Herbarium of Riksmuseum, Stockholm; leg. HJALMARSSON, Honduras, 1852). After acetolization according to ERDTMAN's method the pollen grains were examined both under light microscopes (LM) and with electron microscope (SEM, TEM). The SEM (Jeol 35) and the LM (Zeiss NU and Opton) micrographs were made partly at Eötvös Loránd University, Budapest, partly at Hungarian Geological Institute, Budapest from the same specimen (single grain preparation). Measurements are equatorial (width) followed by polar (length). All the measurements given here are the means of the data measured of twenty acetolyzed pollen grains. The minimum and maximum values of pollen size are also given in parentheses. In the description of pollen morphology mainly ERDTMAN's terminology is used (ERDTMAN 1963).

Description of pollen grain

Pollen grains are small, cca. 20 μm (18–22 μm), isopolar with nearly radiosymmetric shape (Pl. I, 1, 3–4; V, 1–18; VI, 2–19; VII, 8–14; VIII, 1–6), so prolate-spheroidal, puctitegillate (tectate-perforate) (Pl. I–III; IV, 5; V, 20–21), tetracolporate (NPC 445) (Pl. III, 1–6; IV, 1, 4, 16, 20, 23, 27).

Exine is cca. 1 μm thin, infratectal (infrategillar). It consists of a smooth, cca. 0.3 μm thick nexine and an cca. 0.7 μm thick tectate-perforate sexine (Pl. V, 9–11, 19; VI, 10).

Under light microscope (num. ap. 1.4) the columella layer of sexine seems to be "granulate" and the surface seems to be smooth. But the TEM micrograph (Fig. 2.) exhibits, that the columella layer consists of rod-like baculums. (Pl. V, 7, 13, 17–18; VI, 2–8, 12, 17–18; VII, 7; 9–11, 13 VIII, 2–6; Fig. 2.). "Granulums" are cca. 0.2–0.3 μm in diameter. The four colpi are long narrow slits from pole to pole in the sexine (Pl. I–III; IV, 1–4, 7, 16, 20, 23–25; V, 34; VI, 1; VII, 4–5, 13–14; VIII, 8). The pori are light, circular, sub-circular openings, 2–3 μm in diameter. They take place in the equatorial zone, and break through both layers (endexine + sexine) of exine (Pl. I–III; IV, 9–11, 15, 25; V, 1, 4; VI, 2, 16; VII, 3, 9, 13; VIII, 2–4, 7–8).

In the equator 2–3 μm wide, light possible solution area is visible around the pollen grain. Since in this lighter zone the structure of the columella layer is also well visible therefore this solution area should be in the endexine (nexine). (Pl. I, 1; IV, 11–12, 21–23; VI, 2–3, 16, 27; VII, 9; VIII, 4–8).

The thin layer of tegillum (tectum) is continuous with the exception of apertures (Pl. IV, 22). Since under light microscope there is no visible tectum

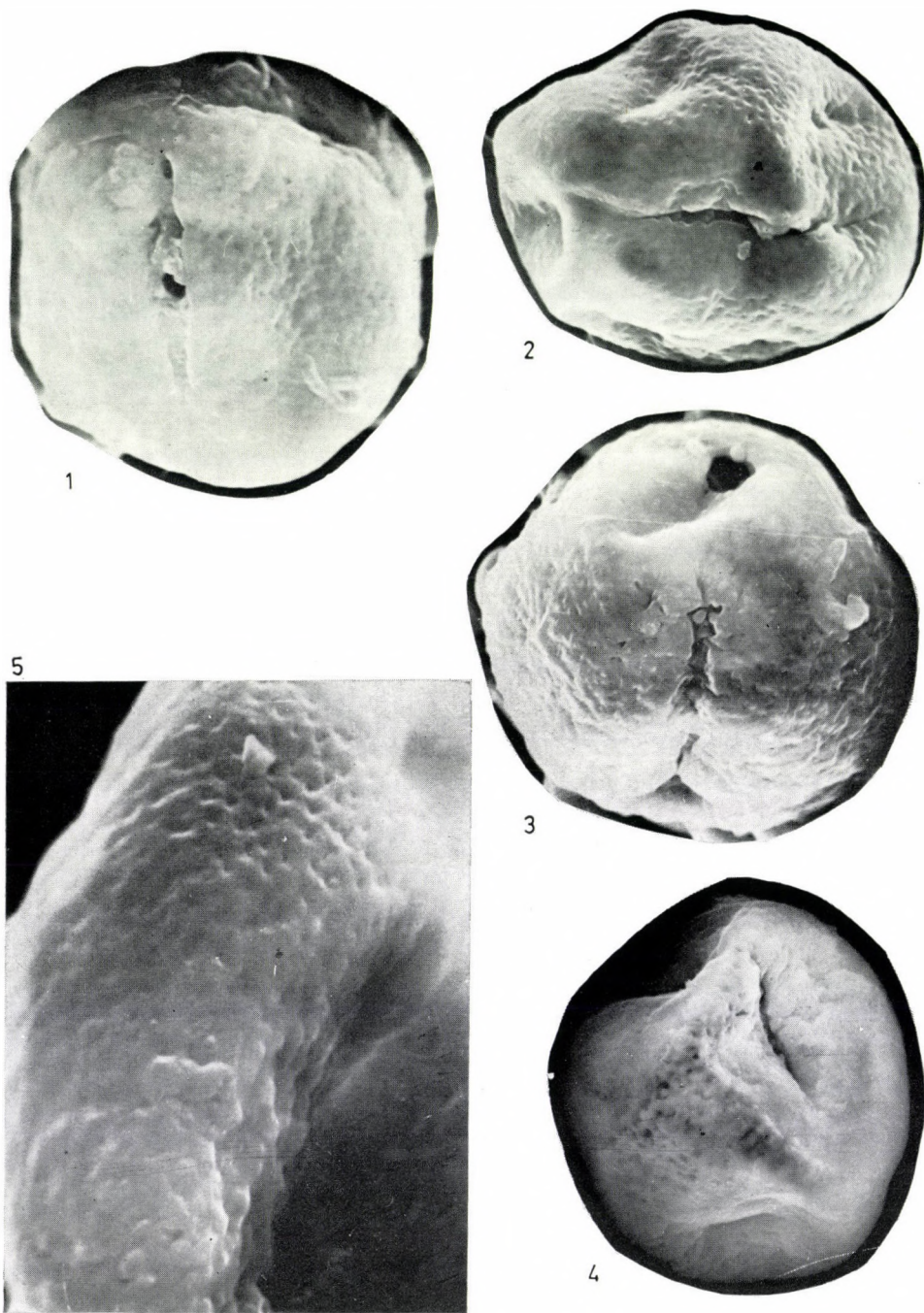
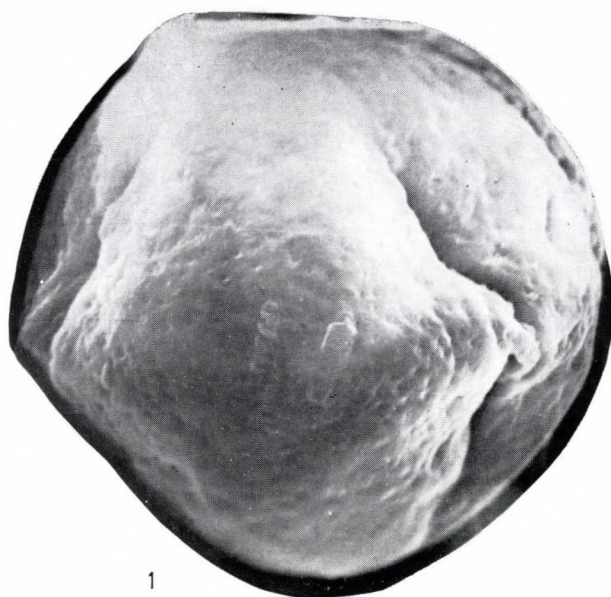


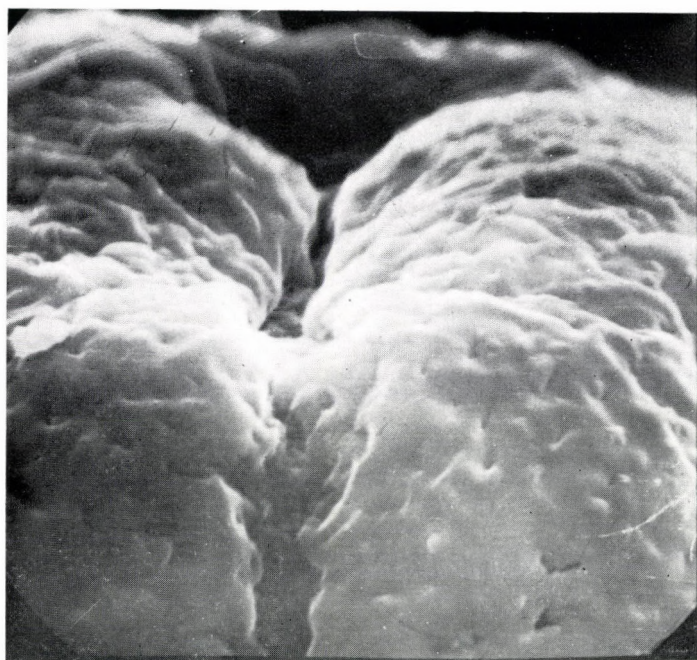
Plate I

1-4. Colpi, pori and solution area of the pollen grains of *Javorkaea hondurensis* (SEM cca $\times 3000$)

5. Punctitegillate sculpture along a colpus (SEM cca $\times 10\ 000$)



1



2

Plate II

1. SEM micrograph of the pollen grain of *Javorkaea hondurensis* (cca $\times 4800$)
2. Narrow slit of a colpus and tectate-perfoate sculpture (SEM cca $\times 10\ 000$)

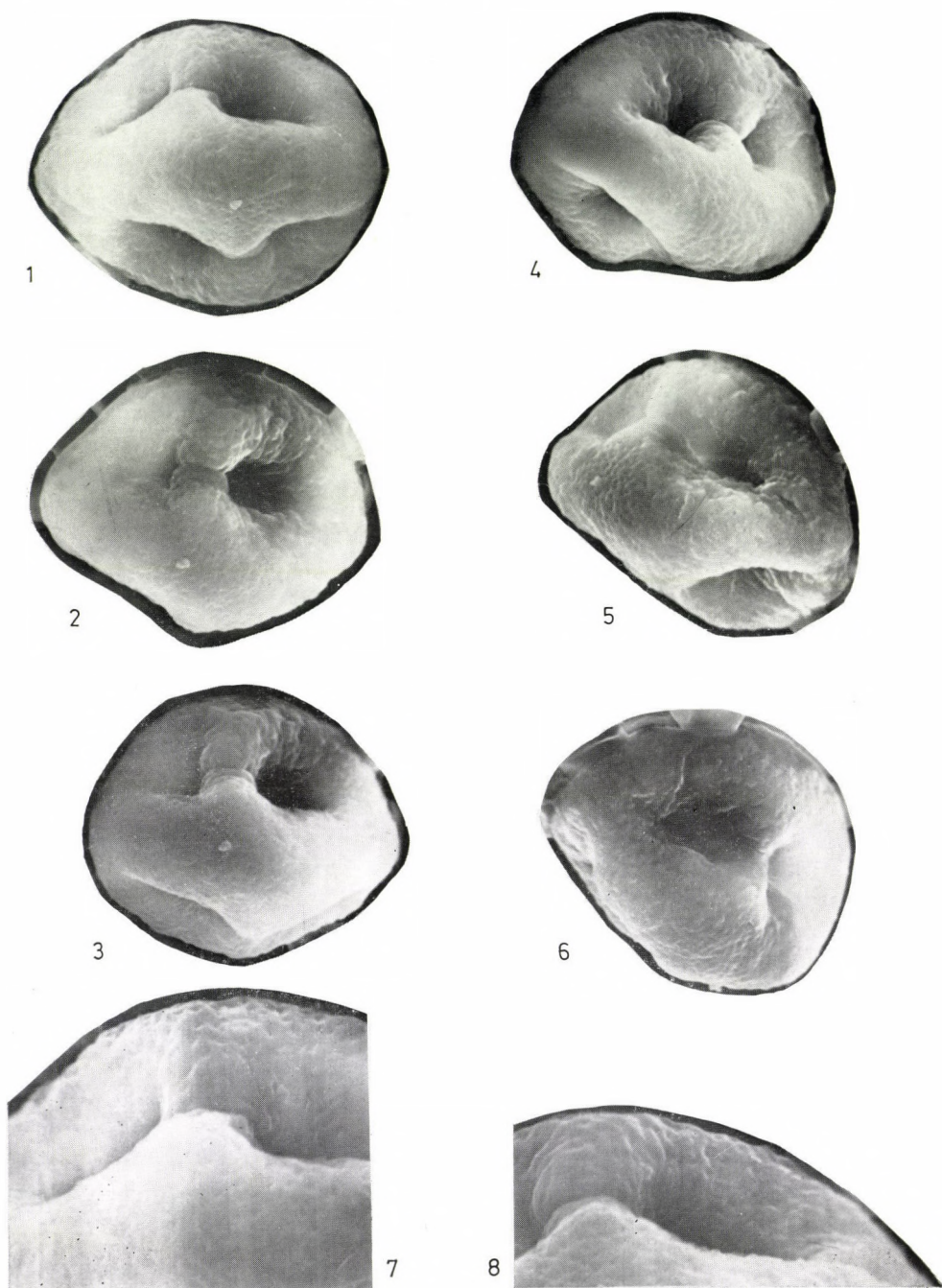


Plate III

1-6. Sinuosited grains of *Javorkaea hondurensis* with apertures in different angle (SEM cca $\times 3000$)

7-8. Colpi (SEM cca $\times 5400$)

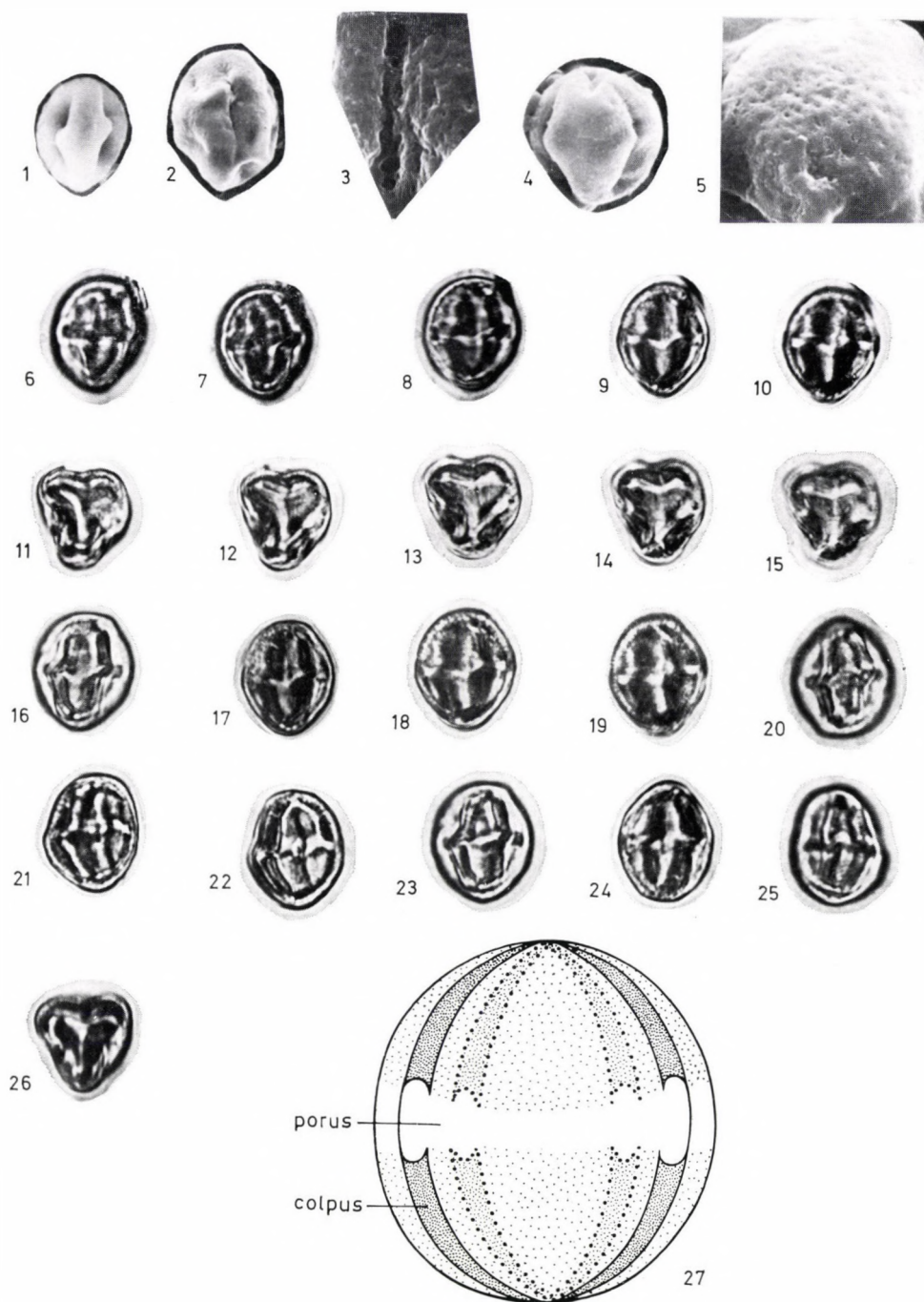


Plate IV

1-3. Sinuosit grain of *Javorkaea hondurensis* (SEM cca $\times 1000$)

4. Part of a colpus (SEM cca $\times 3000$)

5. tectate-perforate sculpture (SEM cca $\times 3000$)

6-26. LO analysis of the same specimen under different foci, from equatorial view on one face through polar view to equatorial view of the other face of the grain (LM cca $\times 1000$). Equatorial view: 6-10 and 16-25; half polar view: 11-15 and 26. SEM and 6-26 LM micrographs made from the same single grain specimen

27. Composite apertures of the pollen grain

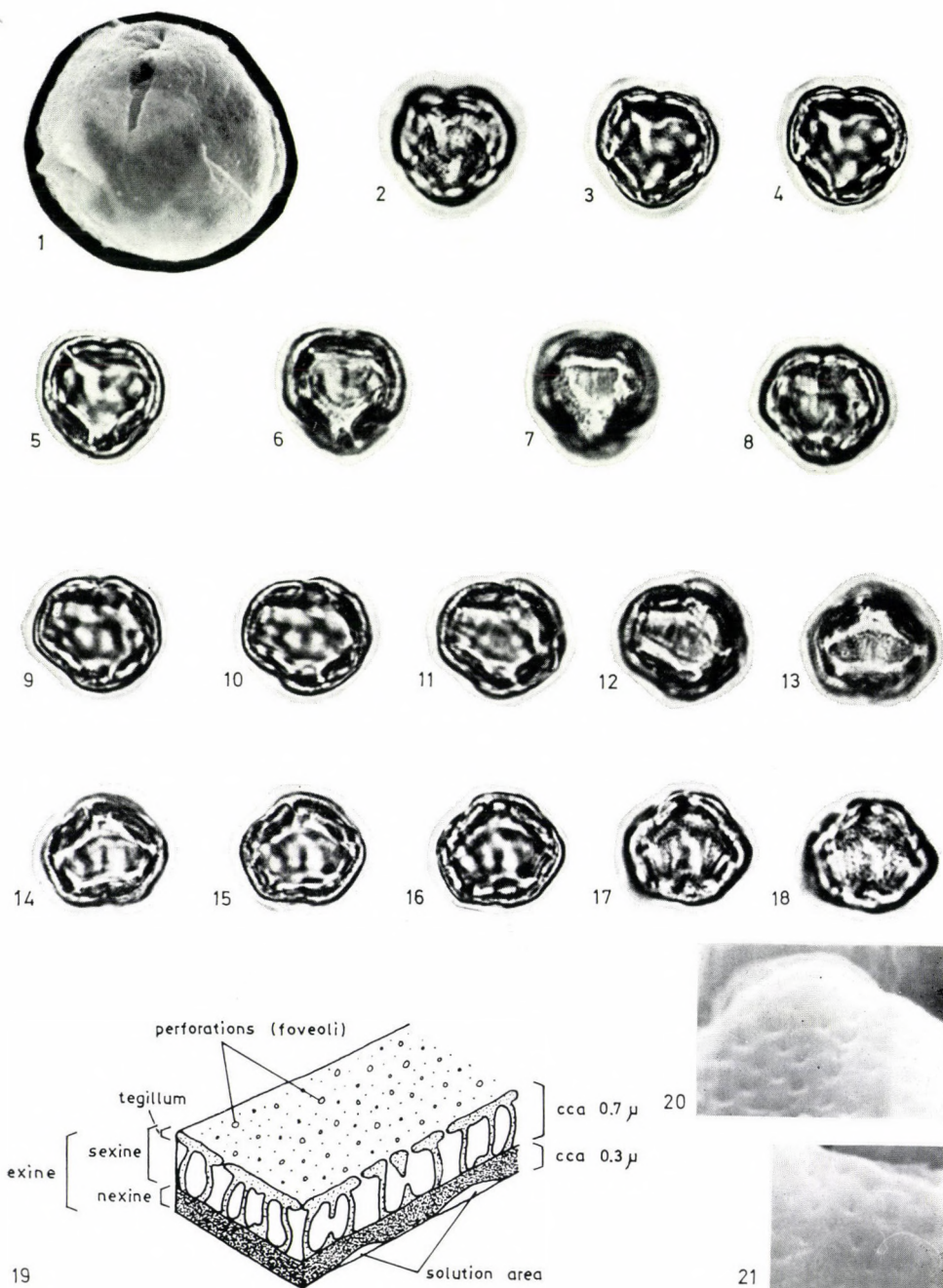


Plate V

1. Colpi, pori and solution area of the pollen grains of *Javorkaea hondurensis* (SEM cca $\times 1800$)
 2–18. LO analysis of the same specimen under different foci and from the different faces of the non sinuated radiosymmetric pollen grain (LM cca $\times 1000$)

19. Sporoderm stratification (SEM and LM micrographs of 1–19 were made from the same single pollen grain specimen)

20–21. Punctitegillate sculpture (SEM cca $\times 10\,000$)



1



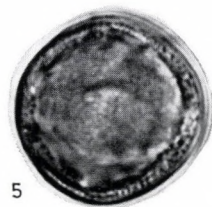
2



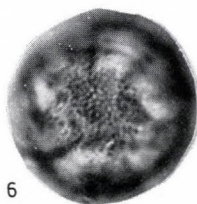
3



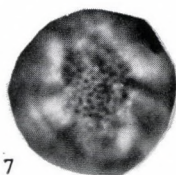
4



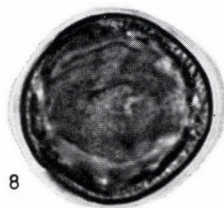
5



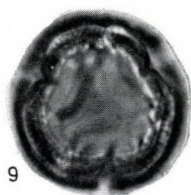
6



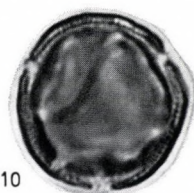
7



8



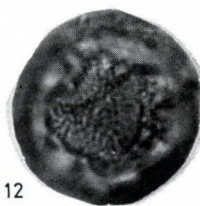
9



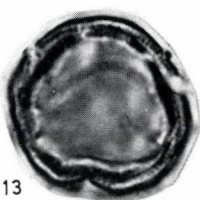
10



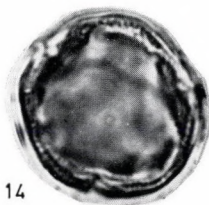
11



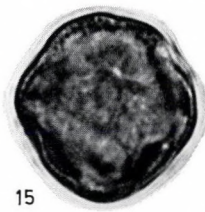
12



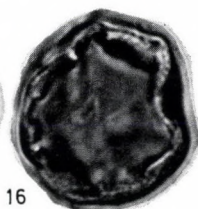
13



14



15



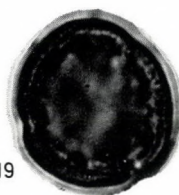
16



17



18



19

Plate VI

1. Part of a colpus of the pollen grain of *Javorkaea hondurensis* (SEM cca $\times 3000$)
 2-19. Radiosymmetric grains under different foci (LM cca $\times 1200$) LM micrographs were
 made from five different specimens (2-4, 5-8, 9-12, 13-16, 17-19)

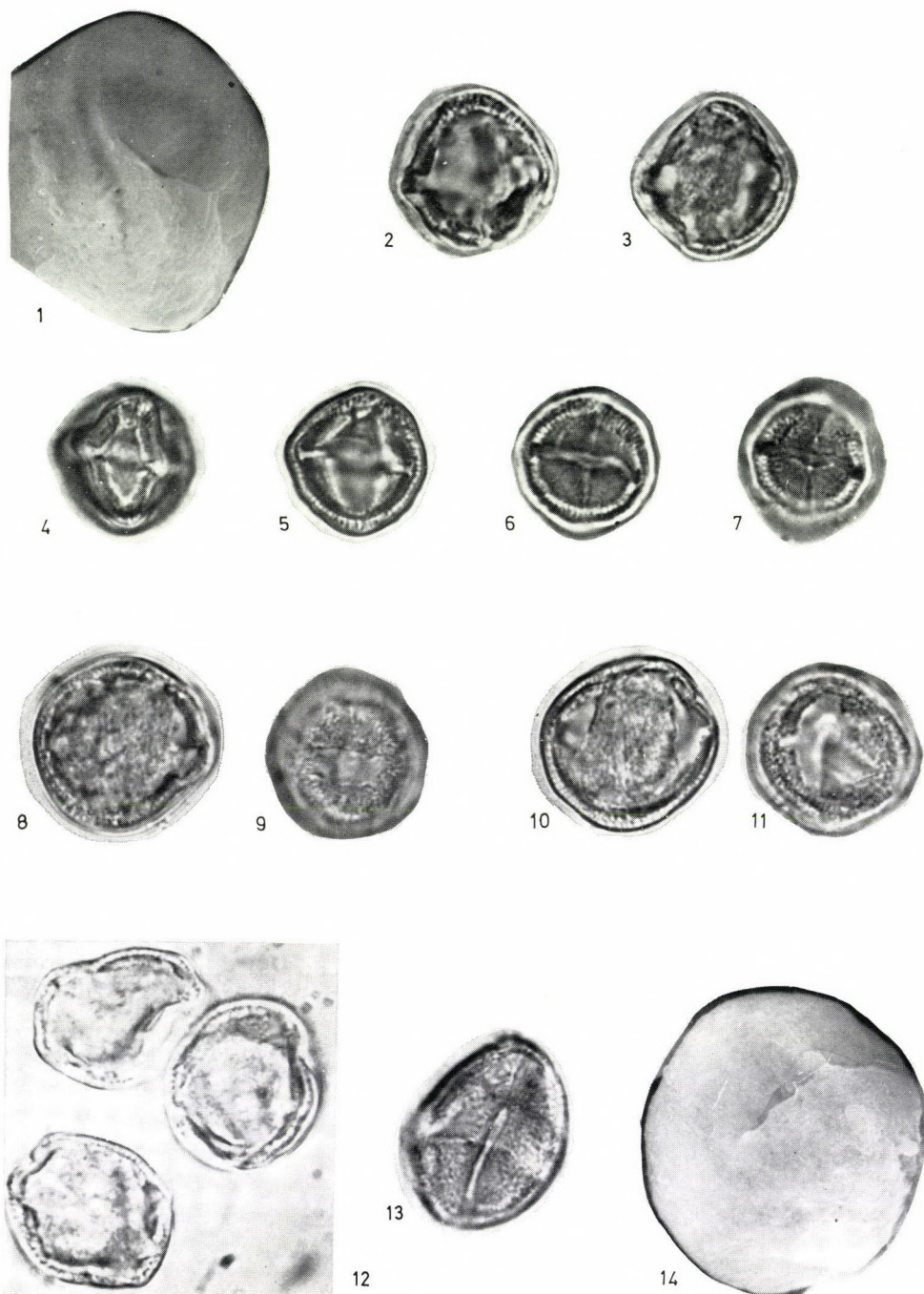


Plate VII

1. SEM micrograph of the pollen grain of *Javorkaea hondurensis* (cca $\times 2400$)
 2-13. LM micrographs of different specimens. 2-3 and 4-7 are more or less sinuosited, 8-9, 10-11, 12 and 13 are radiosymmetric grains (LM cca $\times 1200$)
 14. SEM micrograph cca $\times 2400$

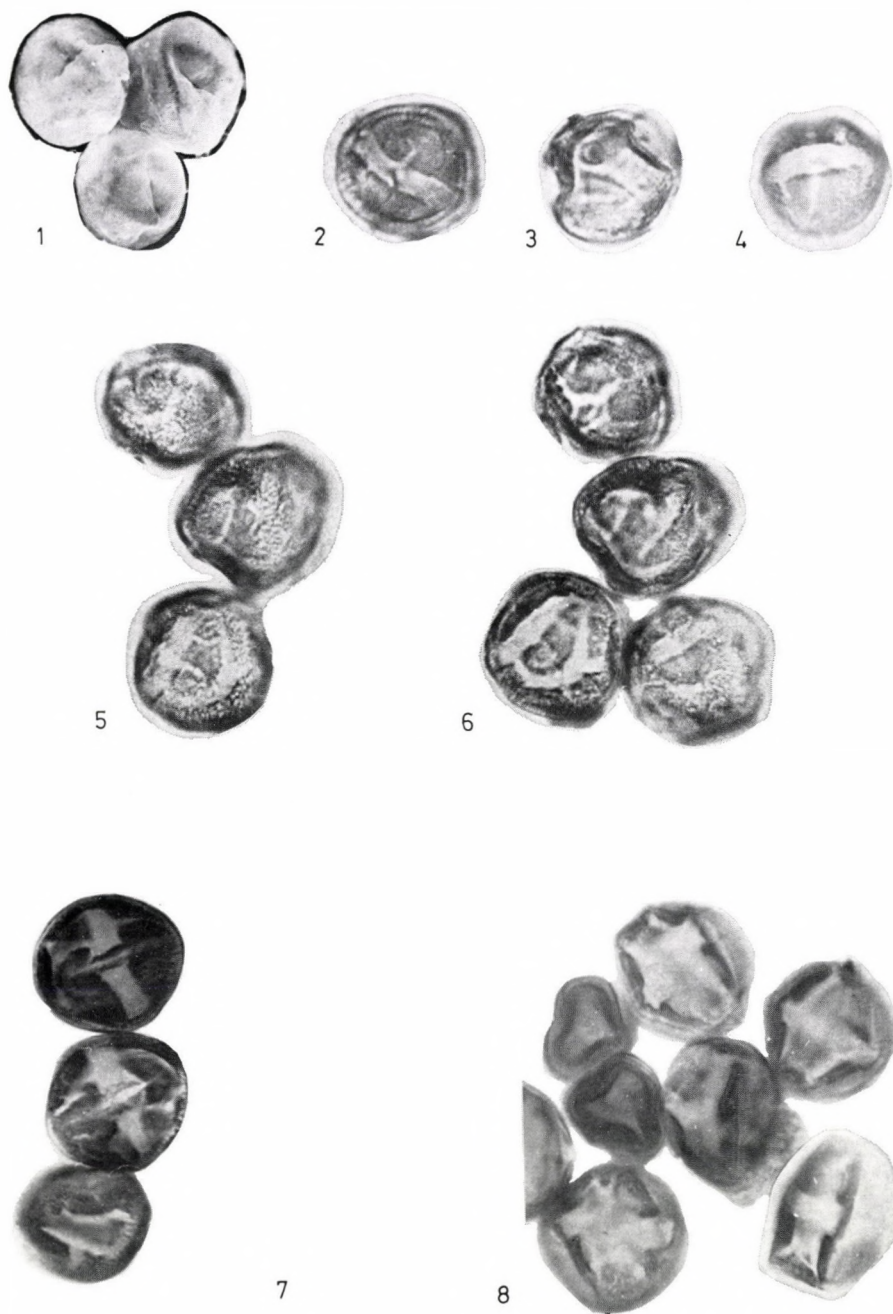


Plate VIII

1. SEM micrograph cca $\times 1000$

2-8. LM micrographs of different specimens. The columella layer seems to be "infrageranulate" on the radiosymmetric grains (2-6). Colpi, meridional solution area and pori are visible both on the radiosymmetric and sinuosit (7-8) grains (LM cca $\times 1000$)



Fig. 2. TEM micrograph of tectate-perforate, simplibaculate structure of exine

and even baculate sexine above the apertures it seems so, that the colpi and the lighter equatorial solution zone divide the tectum in eight, rather equal and symmetric granulate parts (Pl. V, 17–18; VIII, 4–7).

The solution area, situated probably in the endexine, can not be seen on the SEM micrographs because with the exception of the well visible slits of four colpi and circular pori) the whole surface of the sexine is tectate-perforate. The irregularly (cca $0.4 \mu\text{m}$) spaced perforations are cca. $0.2 \mu\text{m}$ in diameter (Pl. I–III; IV, 5; V, 20–21; IX). But in a few cases, when the coating is optimal the solution area is faintly outlined as a darker zone (even on the SEM micrographs) probably due to the fewer outgoing secondary electrons because of the less reflected character of the thinner exine.

TEM micrograph (cca $\times 20\,000$) exhibits the tectate-perforate, simplibaculate structure with more or less equidistantly (cca $0.3 \mu\text{m}$) spaced bacula (cca $0.2 \mu\text{m}$ wide and $0.4 \mu\text{m}$ long), and cca $0.1 \mu\text{m}$ perforations. Footlayer is nearly the half in thickness (cca $0.2 \mu\text{m}$) than the tectum (cca $0.4 \mu\text{m}$). (Pl. IX).

Remarks

The acetolysed spherical pollen grains have sinuosity whereupon the pollen grains often lengthen in the direction of polar axis. In the sinuositised grains—because of the thin exine—both the pori and the colpi are better visible (Pl. III–IV; VII. 2–7; VIII, 7–8). The other consequence of this lengthening is that the pollen grains often seems to be a tricolporate-fossaperturate in polar view (Pl. VIII, 8).

On the radiosymmetric grains the light lines of four colpi and equatorial solution area exhibit a hardly recognisable structure under LM because the spherical grains almost never can be studied in right polar or equatorial position (Pl. V, 2–18; VI, 2–19; VII, 8–11; VIII, 2–6).

In a few cases the upper surface of the tegillum is beset with microgranulums. It can be seen only the 10 000 \times electron micrographs (Pl. II. 2.).

Among the many examined tetracolporate pollen grains a few tricolporate were also found. It is possible due to the contamination of the herbarium material.

ACKNOWLEDGEMENTS

The authors are grateful to Mr. F. GÓCZÁN for his help of making both all the SEM micrographs and some of the LM micrographs, and for his advices in the interpretation of pollen structure.

Special thanks are due to Mr. L. KONDICS for TEM micrographs and to Mrs. É. FAULHABER, Mrs. V. TAKÁCS and Mr. L. OBERRECHT for their technical assistance, and to Mrs. G. GYURKÓ for the beautiful drawings.

REFERENCES

- Aiello, A. (1979): A reexamination of *Portlandia* (Rubiaceae) and associated taxa. *J. Arn. Arb.* **60**: 38–123.
- Borhidi, A. (1982): Studies in Rondeletieae (Rubiaceae) III. The genera *Rogiera* and *Arachnothyx*. *Acta Bot. Acad. Sci. Hung.* **28**: 65–71.
- Borhidi, A., Fernandez, M. Z. (1982a): Studies on Rondeletieae (Rubiaceae) I; a new genus: *Roigella*. *Acta Bot. Acad. Sci. Hung.* **27**: 309–312.
- Borhidi, A., Fernandez, M. Z. (1982b): Studies on Rondeletieae (Rubiaceae) II; a new genus: *Suberanthus*. *Acta Bot. Acad. Sci. Hung.* **27**: 313–316.
- Borhidi, A., Járjai-Komlódi, M., Moncada, M. (1981): *Acunaeanthus*, a new genus of Rubiaceae. *Acta Bot. Acad. Sci. Hung.* **26**: 277–287.
- Bremekamp, C. E. B. (1966): Remarks on the position, delimitation and the subdivision of the Rubiaceae. *Acta Bot. Neerl.* **15**: 1–33.
- Erdtman, G. (1952): Pollen morphology and plant taxonomy. Angiosperms. *The Chronica Botanica Co.*, Waltham Mass. 382–387.
- Erdtman, G. (1963): Palynology. In: *Advances in Botanical Research*. 149–208. Academic Press, London.
- Kirkbride, J. H. jr. (1968): A revision of the Panamanian species of *Rondeletia* (Rubiaceae). *Ann. Mo. Bot. Gard.* **55**: 372–391.
- Standley, P. C. (1918): *Rondeletia*. In: *N. Amer. Flora* **32A**: 44–86.
- Steyermark, J. A. (1967): Rubiaceae. In: Maguire and coll.: *The Botany of the Guyana Highland — Part VII*. *Mem. N. Y. Bot. Gard.* **17**: 241–261.

STUDIES IN RONDELETIEAE (RUBIACEAE), V

LOS LIMITES DEL GÉNERO *SUBERANTHUS*

A. BORHIDI y MAYRA FERNANDEZ ZEQUEIRA

(Received: 1 September 1982)

The authors trace the morphological limits of the recently described genus *Suberanthus*, amplifying its description, giving an analytical key for the determination of its species and other taxa. They describe a new subgenus: *Moscosoa*, a new hybrid and publish some new combinations related to the genus: *Suberanthus* × *angustatus* (Griseb.) Borhidi, *S. hincheanus* (Urb. et Ekm.) Borhidi and *S. pungens* (Urb.) Borhidi.

El género *Suberanthus* fue reconocido y separado del género *Rondeletia* por tener cápsulas septicidas, elípticas u obpiriformes, cubiertas por lenticelas suberosas esparcidas grandes, placentas basales, semillas aladas y fimbriadas y además de estas características, por tener polen grande con un exine reticulado, completamente distinto de lo de la *Rondeletia*, que es foveolado.

Encontramos 5 especies pertenecientes a este género, 3 de las cuales fueron descritas originalmente, como las de otros géneros (*Exostema*, *Ferdinandea*) y las incluyeron con posterioridad en el género *Rondeletia*. Las 5 especies viven en Cuba y una de ellas se encuentra en Española también (*S. brachycarpus*).

Al revisar de las especies de *Rondeletia* y *Neomazaea* existentes en Española se encontraron otras dos especies mas pertenecientes al género *Suberanthus*: *Rondeletia hincheana* Urb. et Ekm. y *Neomazaea pungens* Urb. Ambas especies tienen la estructura característica de la corola, ovario, placenta y polen del género *Suberanthus*. En cuanto a la forma de cápsula, su pubescencia, los lóbulos del cáliz persistentes y el numero de las semillas, estas dos ultimas especies tienen ciertas diferencias comunes, que pueden justificar la decision del autor senior agrupandolas como miembros de un subgénero endémico nuevo de Española, bajo el nombre: *Moscosoa*.

Durante la revisión de las especies cubanas, los autores encontraron, que el *Suberanthus brachycarpus*, la especie de mayor distribución, variabilidad y del mayor vigor aparente, es capaz de formar híbridos interespecíficos con varias otras especies del género, en las areas, donde sus poblaciones se encuentran juntas. Las poblaciones híbridógenas son muy variables porque algunas semejan mas a uno de los parientes, y otras al otro. Se aclaró, que la colección típica de la *Rondeletia angustata* Wr. in Sauv. — en su mayor parte — pertenecía a una población híbridógena, y en esta manera el dicho taxon no es idéntico con la *Rondeletia neriifolia* (A. Rich.) Urb. como lo ha sido supuesto.

La descripción ampliada del género es la siguiente:

Suberanthus Borhidi et Fernandez, Acta Bot. Acad. Scient Hung. 27: 314 (1981 publ. 1982)

Arbustos y arbolitos de hasta 12 m de altura, mayormente inermes, a veces espinosos. Ramitas mayormente cilíndricas, glabras, o mas raras sericeo-pubérulas. Estípulas pequeñas, triangulares, coriáceas. Hojas opuestas, a me-

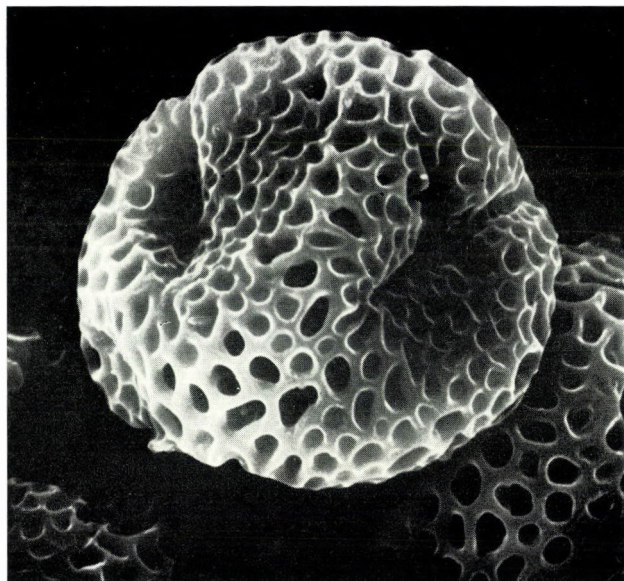


Fig. 1. Grano de polen del *Suberanthus pungens* (Urb.) Borhidi (2000 \times). SEM micrograph by Dr. K. VÁNKY

nudo ternadas, a veces verticiladas, mayormente glabras, coriáceas, con margen entero. Inflorescencias terminales, a veces terminales y axilares, cimosas de cimas mayormente 9-floras, compuestas en un ráncimo tirsiforme mayormente no muy largo. Flores rojo-negruzcas, 4-meras, glabras o sericeas, nunca tomentosas o vellosas. Hipantio obovato-piriforme, o subgloboso-elíptico. Lóbulos del cáliz 4, iguales o desiguales, mas cortos que el hipantio. Corola pequeña, 4-mera, actinomorfa, coriacea, rojo-negruzca; el tubo glabro por dentro, la garganta muy engrosada y estrechada sin calosidades de forma de dientes, lamelas o de anillo, por fuera mayormente glabra mas raramente sericea; lóbulos 4, aovado-orbiculares, imbricadas. Estambres 4, insertos sobre la mitad del tubo, filamentos muy cortos o ausentes, anteras oblongo-elípticas insertas en la garganta, dorsífigas. Estilo brevemente bilobado, completamente lampiño. Disco del ovario anillar, entero, glabro. Grano de polen 3-colporato, elíptico a subgloboso, el exine reticulado, no foveolado, con un retículo ancho, profundamente areolato. Ovario obovado, piriforme o subgloboso-elíptico; placenta obovada u oblongo-elíptica inserta en la base de las celdas, ascendente, coriácea u ósea, verticalmente surcada, óvulos numerosos, verticalmente dispuestos, imbricados. Cápsula piriforme, obovada u oblongo-elíptica, glabra o deprimido-pelosa, mayormente cubierta por lenticelas suberosas grandes, septicida, 4-valva. Semillas discoideas, aladas e irregularmente fimbriadas o lacinadas.

Especie típica: *Exostema neriifolium* A. Rich.

Género endémico de las Antillas Mayores, con 7 especies de Cuba y Española.

Clave analítica para los taxones pertenecientes al género:

- 1 a Cápsula subglobosa o piriforme, cubierta por lenticelas suberosas grandes; lóbulos del cáliz no persistentes en el fruto; hojas de 3–12 cm de largo; semillas 15–25 en cada celda (subgen. *Suberanthus*) 2
- b Cápsula oblonga, deprimido pelosa, sin lenticelas suberosas; lóbulos del cáliz persistentes en el fruto; hojas de 1–4 cm de largo; semillas 5–10 en cada celda (subgen. *Moscossa*) 8
- 2 a Inflorescencia, cáliz y corola glabros 3
- b Inflorescencia, cáliz y corola pelosos a pubérulos, a veces muy esparcidamente ... 6
- 3 a Hojas lanceoladas a obovado-oblongas u oblongo-lanceoladas, agudas u obtusas en el ápice 4
- b Hojas obovadas, redondeadas en el ápice 5
- 4 a Hojas sésiles 1. *S. yumuriensis*
- b Hojas con pecíolos de 3–10 mm de largo 2. *S. neriifolius*
- 5 a Lóbulos del cáliz \pm iguales, deltoideos, agudos, muy cortos 3. *S. stellatus*
- b Lóbulos del cáliz desiguales, aovados a espatulados, de 1–2 mm de largo 4. *S. canellifolius*
- 6 a Hojas escabridulas ad ásperas y mates en el haz, pubérulas a hírtulas en el envés, barbudas en las axilas de los nervios; inflorescencia pubérula 5. *S. brachycarpus*
- b Hojas lampiñas en ambas caras, mayormente lustrosas en el haz; inflorescencia glabrescente 7
- 7 a Hojas aovadas a lanceoladas, lóbulos del cáliz \pm iguales 6. *S. \times angustatus*
- b Hojas obovadas, lóbulos del cáliz desiguales 7. *S. \times nipensis*
- 8 a Planta inermes; hojas elípticas o aovadas, agudas en el ápice, pelosas en las axilas de los nervios del envés 8. *S. hincheanus*
- b Planta virgultosa, a menudo espinosa; hojas obovadas, redondeadas en el ápice, glabras en el envés 9. *S. pungens*

Subgenus: *Suberanthus*

Capsula leviter obovata vel pyriformis, lepidota et lenticellis suberosis magnis oblecta, lobulis calycinis deciduis, plerumque glabra. Placenta obovata, semina 15–25 in quoque loculo.

Suberanthus brachycarpus (Griseb.) Borhidi et Fernandez

— Toda Cuba, Haití y Santo Domingo.

Suberanthus canellifolius (Britt.) Borhidi et Fernandez

— Cuba: Sierras de Nipe, Cristal y Micara.

Suberanthus neriifolius (A. Rich.) Borhidi et Fernandez

— Cuba: Isla de Pinos, Pinar del Río, Habana, Matanzas, Las Villas.

Suberanthus stellatus (Griseb.) Borhidi et Fernandez

— Cuba: Sierra de Moa, Cuchillas de Toa y Baracoa, Monte Líbano, Sierra de Guaso.

Suberanthus yumuriensis (Britt.) Borhidi et Fernandez

— Cuba: Valle del Río Yumuri, al E de Baracoa.

Suberanthus × **angustatus** (Wr. in Griseb.) Borhidi **comb. et stat. novus.** — (*Suberanthus neriifolius* × *brachycarpus*) — Basionymon: *Ferdinandea angustata* Wr. in Griseb. Cat. Plant. Cub. 1866: 127. Syn.: *Rondeletia angustata* Wr. in Sauv. Anal. Acad. Habana 6: 122 (1869).

Frutex caracteribus parientum intermixtis in combinationibus variis manifestis. Rami hornotini glabri, folia lanceolata vel oblongo-elliptica, rariter ovato-elliptica, 4–12 cm longa et 1,5–4 cm lata, apice plerumque acuta, rariter obtusiuscula, basi attenuata et longe vel breviter cuneata, supra nitidula vel paullo opaca, subtus pallida, utrinque glabra, chartacea vel rariter subcoriacea; nervis lateralibus plerumque utrinque obsoletis vel in foliis subcoriaceis supra impressis et subtus prominulis. Inflorescentia terminalis, cymoso-racemosa atque tubus calycis corollaeque extus pilis adpressis sparse vel sparsissime pilosuli. Calycis lobi 4, triangulares, acuti vel ovati, rotundati, plerumque aequales, rariter inaequales mixti. Capsula plerumque subglobosa vel breviter obovata "brachycarpiformis".

A *S. neriifolius* inflorescentiis, calycis atque corollis sparse adpresse pilosis, foliis supra nitidulis vel opacis, rariter nervis lateralibus impressis, textura subcoriaceis, casualiter ovatis vel obovatis et calycis lobis rotundatis capsulaque abbreviata differt.

A *S. brachycarpus* foliis plerumque lanceolatis, acutis, supra nitidulis, essentialiter glabris, nervatione obsoleti, floribusque sparse pilosis, non sericeis, calycis lobis saepe breviter triangularibus, acutis diversus.

Holotypus: CH. WRIGHT 2681 in NY!, Cuba; Pinar del Rio Prov. In paludosis prope Toscano. Isotypi: S. GOET, BM, HAC p.p.

Specimina examinata: Pinar del Rio: ALAIN 51; Sierra del Rosario, serpentine barrens, Zambumbia, Rangel (NY, HAC); Prov. Matanzas: LEÓN 8844; Loma Jacán, San Miguel de los Baños, in decliv. serpent. vallis rivuli, HAC, GH, NY, S. — Prov. Las Villas: HOWARD 5489; Cascajal, open savannas, GH, HAC, NY, US; LEÓN 5295: serpentine hill La Lanza, Manajanabo; GH, HAC, NY, US; HOWARD 422, 433, BRITTON and COWELL 13305, Serpentine barren near Santa Clara, A, GH, HAC, MICH, NY, US; ALAIN 1537, 1586, Savannas SE of Sancti Spiritus GH, HAC, NY, US.

En la colecta nr. 2681 de CH. WRIGHT descrita como *Ferdinandea angustata* Wr. in Griseb. se encuentran ejemplares de dos poblaciones distintas. Una de estas corresponde a la especie *Exostema neriifolium* A. Rich. in SAGRA XI: 7. 1850; como lo determinó URBAN [Symb. Ant. 9: 514 (1928)] hundiendo el nombre de WRIGHT en la sinonimia. Según nuestro concepto, la otra — y mayor — parte de los ejemplares pertenece a un híbrido intermediario entre *Suberanthus neriifolius* y *S. brachycarpus*. La participación de la especie *S. neriifolius* y del híbrido en los ejemplares distribuidos en los distintos herbarios son muy diferentes. En el ejemplar de NY ninguno de las dos ramitas representan el *Suberanthus neriifolius*, sino ambas pertenecen al híbrido. Este explica lo, que BRITTON conociendo este ejemplar, describió el *Suberanthus neriifolius* nuevamente como *Rondeletia calcicola*. WRIGHT aparentemente consideró las dos poblaciones como variaciones naturales de la misma especie y su descripción no permite decidirlo, que para cual de las dos poblaciones refiere el diagnóstico. Pues la mayor parte de la colecta nr. 2681 de WRIGHT representa el híbrido y la menor cantidad del material representa el *Suberanthus neriifolius*.

folius (A. Rich.) Borhidi et Fernandez, preferimos no hundir el nombre de WRIGHT como sinónimo de esta última especie, sino mantenerlo válido aplicándolo para el híbrido.

Suberanthus × nipensis Borhidi et Fernandez **hybr. nova**

(*Suberanthus canellifolius* × *brachycarpus*)

Frutex; rami hornotini glabri, folia ternata, obovata vel oblongo-obovata, apice rotundata, obtusa vel rariter brevissime apiculata, 4–10 cm longa et 2–3.5 cm lata, basi longe cuneata et in petiolum protracta, supra nitida, subtus opaca, pallida, utrinque glabra vel ad nervo medio sparsissime pilosa et scabridula, nervis lateralibus supra impressis, subtus prominulis. Inflorescentiae terminales, cymoso-racemosae, calycibus corollisque adpresse pilosae. Calycis lobi 4, ovati, semiorbiculares vel spathulati, apice rotundati, plerumque inaequales. Fructus non visus.

Holotypus: EKMAN 1812; Cuba, Oriente, Sierra de Nipe, prope Rio Piedra, in pinetis locis saxosis (S).

Specimina examinata: EKMAN 2155; Cuba, Oriente, Sierra de Nipe, prope Rio Piedra, loc. humidis in pinetis (S). — LEÓN 19158; Cuba, Oriente, Sierra de Nipe, pinelands near Woodfred. Alt. 600 m. (GH, HAC, NY).

A *S. canellifolio* (Britt.) Borhidi et Fernandez inflorescentiis, calycibus corollisque pilosis, foliis subtus ad nervo medio scabridulis diversus; a *S. brachycarpo* (Griseb.) Borhidi et Fernandez foliis supra nitidis, practice glabris, calycis lobis plerumque late ovatis, inaequalibus differt.

En este híbrido la pelosidad del *S. brachycarpus* se manifiesta mas acentuadamente que en el *S. × angustatus*, debido al hecho, que las poblaciones orientales del *S. brachycarpus* tienen una pubescencia mucho mas fuerte y densa en las hojas e inflorescencias, de la que tienen sus poblaciones en Cuba central y occidental.

Subgenus: **Moscsoa** Borhidi **subgen. nova**

Capsula oblongo-elliptica, adpresse pilosa, sine lepidibus et lenticellis suberosis, apice lobis calycinis persistentibus coronata. Placenta oblongo elliptica, semina 5–10 in quoque loculo. Frutices ramulis virgatis, rariter spinosis, microphyllis.

Typus subgeneris: *Rondeletia hincchana* Urb. et Ekm.

El subgénero *Moscsoa* Borhidi se distingue del subgénero típico de *Suberanthus* en tener cápsula alargado-elíptica, deprimido-pelosa, sin escamas y lenticelas suberosas, con lóbulos del cáliz persistentes en el ápice del fruto. Su placenta es alargado elíptica y semillas 5–10 en cada celda. Las dos especies pertenecientes aquí son frutices microfilos con ramitas virgatas, a veces espinosas. Subgénero endémico de Española con 2 especies:

Suberanthus hincchaneus (Urb. et Ekm.) Borhidi **comb. nova**

— Basionymon: *Rondeletia hincchana* Urb. et Ekm. Ark. Bot. 22A 5: 114 (1929) — Española: Haití, Santo Domingo

Suberanthus pungens (Urb.) Borhidi comb. nova

— Basionymon: *Neomazaea pungens* Urb. Ark. Bot. 21A 4: 83 (1927) — Española: Haití

El subgénero *Moscosoa* esta dedicada al honor del ilustre botánico dominicano, R. M. Moscoso, auctor del Catálogo de la flora de Española.

AGRADECIMIENTOS

Los autores expresan sus agradecimientos a los directores y curadores de los herbarios A, BM, BP, GH, GOET, HAC, K, MICH, NY, S, UPS, US, por haber enviado sus materiales para las investigaciones taxonómicas. El estudio fue apoyado por el convenio bilateral firmado por las Academias de Ciencias de Cuba y de Hungría respectivamente, como una contribución al proyecto Nueva Flora de Cuba. Los autores son agradecidos al Dr. K. VÁNKY, micólogo de la Universidad de Uppsala, por haber confeccionado la foto electronmicroscópica del polen del *Suberanthus pungens*.

BIBLIOGRAFIA

- Borhidi, A., Fernandez, M. Z. (1982): Studies in Rondeletieae (Rubiaceae), I. A new genus: *Roigella*. *Acta Bot. Acad. Sci. Hung.* **27**: 309–312.
Borhidi, A., Fernandez, M. Z. (1982): Studies in Rondeletieae (Rubiaceae), II. A new genus: *Suberanthus*. *Acta Bot. Acad. Sci. Hung.* **27**: 313–316.
Borhidi, A., Járαι-Komlódi, M., Moncada, M. (1980): *Acunaeanthus*, a new genus of Rubiaceae. *Acta Bot. Acad. Sci. Hung.* **26**: 277–287.

STUDIES IN RONDELETIEAE (RUBIACEAE), VI

ESTUDIO TAXONÓMICO DE LA RONDELETIA ODORATA JACQ.

MAYRA FERNANDEZ ZEQUEIRA Y P. HERRERA OLIVER

INSTITUTO DE BOTÁNICA, ACADEMIA DE CIENCIAS DE CUBA, LA HABANA, CUBA

(Recibido: 15 November 1982)

The description of *Rondeletia odorata* Jacq. is revised and extended. At the classic locality lectotype specimen was collected and selected. Two infraspecific taxa new to science: ssp. *grandifolia* and ssp. *bullata* are described. *R. odorata* var. *breviflora* Hooker is based on a type specimen having obvious teratological features in the flowers, consequently the name must be considered as an illegitimate one.

La especie *Rondeletia odorata* Jacq. está comunicada para Panamá y todas las provincias cubanas, excepto las antiguas de Camagüey y Oriente y la Isla de Pinos (hoy Isla de la Juventud). Aparece en casi todos los tipos de suelos (calizos, serpentínicos, pizarrosos, lateríticos) y de vegetación (cuabales, manigua costera, bosques a orillas de ríos, bosques semi-decíduos, mogotes).

A muchos botánicos anteriores les llamó la atención la diversidad de aspecto que presenta la especie en el campo y el polimorfismo ecológico y vegetativo inherentes a este taxon. *R. odorata* no tiene preferencia por suelo alguno, se deja cultivar con facilidad y no tiene exigencias hídricas especiales. Por todos estos motivos y por su distribución disyunta Cuba-Panamá es que se ha emprendido este estudio taxonómico.

NICOLAUS JOSEPH JACQUIN al describir la especie (1788) hace un estudio minucioso de la misma, sin embargo consideramos que algunos caracteres tanto vegetativos como florales pueden enriquecerse.

El estudio realizado por J. H. KIRKBRIDE, Jr. (1969) de las especies panameñas del género *Rondeletia*, muestra que la especie *R. odorata* Jacq. var. *breviflora* Hooker es un taxon diferente de los que viven en Cuba, presenta caracteres peculiares tanto en el número y forma de los lóbulos del cáliz y la corola como en su habitat, está restringida a la Zona del Canal de Panamá, donde fue colectada y no se encuentra localizada en Cuba como reporta KIRKBRIDE.

En la tabla 1 se muestran comparativamente algunos aspectos analizados por nosotros y los autores anteriores.

Con el fin de ubicar correctamente los taxones que viven en Cuba, se midieron largo y ancho de las hojas y frutos, largo del cáliz y la corola, del pedúnculo de la inflorescencia y del pecíolo, procesándolos y evaluándolos posteriormente según los valores encontrados en el índice o relación (R) largo/ancho de la hoja. Además, entre los rasgos vegetativos, se analizaron la calidad y densidad de la pubescencia en las ramitas y todas las partes mencionadas, ecótopo, aspecto del secado, consistencia y margen foliar; forma tanto de las partes florales como vegetativas y el grado de compactación de la inflorescencia.

El análisis de todas las características necesarias para este tipo de estudio evidencia que en la descripción de la especie deben ser incluidos los siguientes caracteres:

1. Las estípulas son cuspidadas o subuladas, no atenuadas, a veces muy anchas en la base

2. La base foliar a veces es acorazonada



Fig. 1. *Rondeletia odorata* Jacq. ssp. *odorata* población en la localidad clásica, en Habana

3. El ápice foliar puede ser cuspidado o cortamente acuminado
 4. El envés foliar es pubescente a glabro, estrigoso a glabrescente en los nervios
 5. A medida que la pubescencia en el envés se hace más laxa, se distinguen barbas en las axilas de los nervios primarios para la mayoría de los ejemplares estudiados (con ampliación óptica generalmente)
 6. La transición entre las hojas normales y las brácteas florales es muy variable y se hace difícil en muchos casos distinguir el último par de hojas normales de las brácteas florales
 7. Las bracteolas, no mencionadas en la descripción, raras veces difieren de los lóbulos del cáliz en forma y medidas
 8. El tubo del cáliz (hipanto) es densamente seríceo
 9. Las flores pueden ser 4-5-6(-7)-meras
 10. La corola es rojo-naranja-salmón, a veces escarlata
 11. El tubo de la corola es hirsutico a retrorso-peloso, con todas las formas intermedias entre ambos caracteres
 12. El tubo de la corola tiene largo variable, hasta de 2 cm
- La especie se caracteriza por tener rasgos vegetativos muy variables de acuerdo al ecótopo y caracteres sexuales muy estables.
- La exposición, sobre todo, influye acentuando en mayor o menor escala las características del taxon; por ejemplo: a la sombra disminuyen las abolladuras, aumenta el tamaño de las hojas y flores y aumenta la pelosidad.

La separación de los ejemplares por tipos de vegetación no introdujo diferencias a nivel vegetativo que permiten separar, a partir de la especie, nuevos taxones para la ciencia.

Rondeletia odorata Jacq. Enum. Pl. Carib. 16

Syn.: *R. obovata* L., error tipográfico. Syst. ed. XII. 163

R. speciosa Lodd. Bot. Cab. t. 1893; Paxt. Mag. Bot. II (1836) 242

Arbusto de hasta 2 m, a veces colgando de las rocas, ramas glabras, ramitas ferrugíneo-hirsuticas; estípulas triangulares, cuspidadas o subuladas, a veces muy anchas en la base, de 2–10 mm, seríceas; pecíolo de hasta 8 mm, a veces subnulo; hojas acovadas a ovales, oval-oblongas, obovado-oblongas u obovado-elípticas, de 1–12 por 0.5–6(–7) cm, obtusas a acorazonadas en la base, redondeadas a cuspidadas o cortamente acuminadas en el ápice, coriáceas a membranosas, glabras a escabrosas en el haz, el envés pubescente o glabro y estrigoso o glabrescente en los nervios, con barbas visibles en las axilas de los nervios primarios, nervios laterales 4–6(–7) pares, muy prominentes en el envés en dependencia de las abolladuras del haz, margen plano a muy revuelto; infl. en cimas corimbosas, a veces algo capituliformes, transición entre hojas normales y brácteas florales variable, pedúnculos de hasta 5 cm, pedicelos de hasta 1 cm, bracteolas generalmente no diferentes en forma y medidas de los lóbulos del cáliz: hipantio densamente seríceo, globoso, lóbulos 5 o 6, lineal-espatulados, de hasta 1 cm, obtusos o agudos, algo pelosos; corola asalvillada, rojo-naranja-salmón, a veces escarlata, el tubo hirsutico a retrorso-peloso, de hasta 2(–3) cm, lóbulos 4 u 6(–7), de hasta 5 mm; estambres 5, fijos en la garganta de la corola, ligeramente exsertos, anteras oblongo-elípticas, de 2–2.5 mm; estilo delgado, lineal, hirsuto, al menos en su tercio inferior, estigmas 2; cápsula globosa, de hasta 5 mm, pelosita; semillas numerosas, angulosas, diminutas. — Cuabales, maniguas costeras y bosques: Pinar del Río, La Habana, Ciudad de la Habana, Matanzas, Villa Clara, Sancti-Spíritus, Cienfuegos. — Endémica.

Se comunica su fragancia: “odore violarum suavissimo” (JACQUIN, 1788), pero hasta el presente no se ha vuelto a detectar.

Holotypus: Linn. Syst. 177: Pl. americ. pict. tab. 61 (ramulus florifer).

Lectotypus: HAC 29780. Prov. Ciudad de la Habana: antigua batería de Santa Clara (“Hotel Nacional”), Vedado. Julio 7, 1982. Leg.: M. FERNÁNDEZ y P. HERRERA.

La subdivisión taxonómica es la que sigue:

R. odorata Jacq. ssp. *odorata*

Hojas de tamaño variable, desde 1 hasta 6 cm, margen revuelto a muy revuelto, base acorazonada a subacorazonada, pecíolos breves, de 0.5–2 mm, nervios bien prominentes en el envés, el haz abollado; lóbulos de la corola 4 a 7. R variable. Corresponde a serpentina excepto la zona latosólica de Cajalbana y caliza costera.

Area: Cuabales y maniguas costeras: La Habana, Ciudad de la Habana, Matanzas, Villa Clara. — Endémica.

Table 1

Comparación de las descripciones de JACQUIN, HOOKER (*sensu* KIRKBRIDE 1969), FERNÁNDEZ et HERRERA y ALAIN para *Rondeletia odorata* Jacq.

	JACQUIN	HOOKER	FERN. et HER.	ALAIN
<i>Porte</i>	Arbusto no elegante, desordenado, erecto	Arbusto	Arbusto	Arbusto
<i>Altura</i>	6 pies	—	1.5–2 m	2 m
<i>Ramas</i> forma pubescencia	cilíndricas glabras	cilíndricas glabras	— glabras	— glabras
<i>Ramitas</i> forma pubescencia	— vellosas	— ferrugíneo-hirsutas	— ferrugíneo-hirsutas	— ferrugíneo- o fulvo-hirtulas
<i>Hojas</i> forma	subaovadas	subaovadas a elípticas o subobovadas	aovadas, elípticas, obovado-elípticas, etc.	ovales, ovaloblongas, oblongas, oblongas u obovado-oblongas
consistencia	—	—	membranosas a coriáceas	mayormente coriáceas
ápice	obtusiúsculas	subagudas	aguditas, cuspidadas, etc.	redondeadas a agudas
base	—	subacorazonada	obtusa a acorazonada	obtusa a subacorazonada
pubescencia	escabrositas	densamente escabrosas	glabras a escabrosas envés con barbas	muy escabrosas en el haz estrigosas en los nervios por el envés
margen pecíolo	entero breve	entero breve	entero, a veces revuelto de hasta 5 mm	a menudo revuelto —
<i>Inflorescencia</i>	descripción compleja, obsoleta	tirso contraído	cima corimbosa	cimoso-corimbosa
fragancia	suave olor a violetas	no reportada	no detectada	no detectada
<i>Flores</i> anillo faucial*	pequeñas, bellas protuberante, dorado	pequeñas ca 0.4 mm de grosor	tamaño variable, vistosas protuberante, amarillo	— —
Habitat	Habana, en matorrales rupestres, costeros, casi siempre en las concavidades de las rocas	Zona del Canal de Panamá; no reporta nicho	Todas las provincias de Cuba, excepto Cam., Or. e Isla de la Juventud	LV., Mat., Hab., PR.; Panamá

Floración y fructificación	estaba en flor y fruto en enero	—	Todo el año	—
<i>Cáliz</i>				
lóbulos	5(–6), persistentes, oblongos, cóncavos, agudos, erectos	6, estrechamente oblongos	5(–6), persistentes, lineal-espátulados, agudos	5, lineales a lineal-espátulados, obtusos o agudos
<i>Corola</i>				
tubo	infundibuliforme cilíndrico-erecto, 3 veces más largo que el cáliz, levemente ensanchado arriba	5–7 mm	asalvillada 2(–3) cm, ensanchado hacia la garganta	1.5 cm
lóbulos	5(–6), suborbiculares, obtusos, 3 veces más cortos que el tubo	5, obtusos, de 2.8 mm	4 a 7, suborbiculares a orbiculares, crenados, de hasta 5 mm	5, redondeados, de hasta 3.5 mm
color	—	rojo brillante	rojo-naranja-salmón o escarlata	rojo-naranja
<i>Estambres</i>	5	5	5	5
<i>Gineceo</i>				
ovario	subgloboso	redondeado	subgloboso	globoso
estilo	filiforme, erecto, mucho más breve que los estambres	grueso y glabro	delgado, lineal, más breve que los estambres	—
estigmas	2, oblongos, engrosados, divergentes	2 o 3	2	—
<i>Fruto</i>	subgloboso, coronado por el cáliz, bilocular	<i>non viso!</i>	globoso, bilocular, coronado por el cáliz	cápsula globosa
semillas	muchas, romboideas, diminutas	—	muchas, diminutas, angulosas	—

* Nota: JACQUIN le llama “margen del tubo corolino”. HOOKER lo cita como “callosidad del orificio de la corola”.

R. odorata Jacq. ssp. **grandifolia** Fernández et Herrera, ssp. **nova**

A typo differt: foliis magnis usque ad 12 cm longis et 7 cm latis, margine plano vel subrevoluto, basim rotundatis vel obtusis, petiolis longis usque ad 5 mm, nervis lateralibus subtus conspicuis sed non prominentibus. Relatio long/lat foliorum variabilis.

Holotypus: HAC(LS) 19047. Prov. Pinar del Río. Ensenada de Las Delicias, Viñales. Julio 20, 1939. Leg.: LEÓN, CLEMENTE y LYONNET.

Hojas grandes, de hasta 12 cm, margen generalmente plano a subrevoluto, base redondeada a obtusa, pecíolos largos, de hasta 5 mm, nervios marcados en el envés pero no prominentes. R variable. Corresponde a bosques sobre caliza o suelos derivados de caliza.

Area: Bosques: Pinar del Río, La Habana, Ciudad de la Habana, Matanzas, Cienfuegos, Villa Clara, Sancti-Spíritus. — Endémica.

R. odorata Jacq. ssp. **bullata** Fernández et Herrera, ssp. **nova**

A typo differt: foliis bullatis medianis usque grandis, margine revoluto, basim rotundatis vel subcordatis, petiolis variabiliter longis, nervis supra valde impressis subtus crassiuscule prominentibus, inflorescentiis compactis, ramis, foliis atque inflorescentiis hornotinis fulvo- vel ferrugineo-hirsutis.

Holotypus: HAC 27714. Prov. Pinar del Río. Cajalbana. Noviembre 14, 1974. Leg.: R. OVIEDO et V. SÁNCHEZ.

Hojas abolladas, de tamaño variable, medianas a regularmente grandes, margen revoluto, base redondeada a subacorazonada, pecíolos de longitud variable, nervios hundidos y bien marcados en el haz, muy prominentes en el envés, producto de las abolladuras; inflorescencias más compactas que en los otros casos. Es el taxon más fulvo-hirtulo en las ramitas, flores y frutos jóvenes. Por su aspecto xerófito pertenece al primer grupo y por el tamaño foliar al segundo. R menor que dos. Vive sobre serpentina o suelos derivados de ella.

Area: Lugares húmedos: Cajalbana, Pinar del Río. — Endémica.

Esta última subespecie, a pesar de su aislamiento, la estabilidad floral no permite proponerla como nueva especie.

Se tomó en cuenta el aislamiento geográfico y ecológico que presentan los distintos grupos estudiados y por ello consideramos que desde el punto de vista taxonómico tienen la jerarquía de subespecies.

Clave ecotópica de los taxones infraespecíficos de la especie *Rondeletia odorata* Jacq.

- | | |
|---|-------------------------|
| 1 a Sobre rocas serpentínicas y suelos derivados de ellas | 2 |
| b Sobre rocas no serpentínicas | 3 |
| 2 a Sobre serpentinas y latosoles de Cajalbana | ssp. <i>bullata</i> |
| b Sobre serpentinas y suelos derivados de ellas, excepto la zona de Cajalbana | ssp. <i>odorata</i> |
| 3 a Sobre rocas calizas costeras | ssp. <i>odorata</i> |
| b Sobre rocas calizas ribereñas y montanas, no costeras | ssp. <i>grandifolia</i> |

R. odorata Jacq. var. **breviflora** Hooker. Curtis Bot. Mag. tab. 6350 (1878)

Difiere radicalmente de las subespecies cubanas en que presenta lóbulos del cáliz siempre en número de 6, estrechamente oblongos, tubo de la corola de hasta 7 mm de largo, lóbulos en número de 5, obtusos, estambres fijos en

la mitad del tubo de la corola, totalmente incluidos, connados en la base del tubo corolino con el estilo, anteras elíptico-sagitadas, asimétricas en la base, de 1-1.5 mm, estilo grueso, anguloso y glabro, estigmas 2 o 3.

Estos últimos caracteres se corresponden con el ejemplar estudiado del Herbario Kew, con etiqueta del Hort. Kew, Jan. 1878.

COWELL 359 (NY.), colectado en la Zona del Canal de Panamá, Matachín a las Cascadas, citado por KIRKBRIDE (1969), también presenta caracteres similares a los del individuo cultivado en los jardines del Kew Bot. Garden.

Como el ultimo ejemplar de COWELL no hemos logrado ad estudiar, no podemos opinar su posición taxonómica. Pero el ejemplar típico tiene características muy peculiares, completamente insólitas y ajenas en el género *Rondeletia*, como los estambres insertos en la mitad del tubo de la corola, los filamentos connados entre si y con la base del tubo corolino, el estilo anguloso, grueso y glabro. Si el ejemplar no presentara una identidad tan grande en todos los demás caracteres vegetativos y generativos morfológicos, no excluiríamos la posibilidad, de que se trate de un género nuevo, no descrito. Sin embargo, es mucho mas probable, que el ejemplar típico de la var. *breviflora* tuviera una evolución irregular de sus flores, del caracter teratológica, y el desarrollo anormal de los estambres provocó la abbreviatura del tubo de la corola, que fue designada como la característica diferencial de la variedad. Tenemos que mencionar, como un motivo importante, que la var. *breviflora* no se ha resultado colecta en fructificación. Concluyendo consideramos, que la *R. odorata* var. *breviflora* Hooker esta descrita en la base de una forma teratológica, consequentemente el taxon no es válido y cae en la denominación de *nomen illegitimum*. De esto se infiere que la especie es endémica de Cuba.

RECONOCIMIENTO

Agradecemos al Prof. A. BORHIDI, por la revisión critica de este trabajo, asi, como a los compañeros O. BABILONIA y R. SOLIS, por los dibujos y fotos respectivamente.

REFERENCIAS

- Alain, H. Liogier (1964): *Flora de Cuba*. Vol. 5. La Habana
 Jacquin, J. N. (1788): *Selectarum Stirpum Americanarum Historia*. Vienna
 Kirkbride, J. H. Jr. (1969): A revision of the Panamian species of *Rondeletia* (Rubiaceae). *Ann. Mo. Bot. Gard.* 55: 372-391.

STUDIES IN RONDELETIEAE (RUBIACEAE), VII

THE SIGNIFICANCE OF LEAF EPIDERMIS FOR TAXONOMY IN *NEOMAZAEA* SENSU LATO

M. A. VALES

BOTANICAL INSTITUTE OF THE ACADEMY OF SCIENCES OF CUBA, HAVANA, CUBA

(Received: 15 November 1982)

The leaf epidermal characters of the three species belonging to the genus *Neomazaea* sensu Urban (1927) are described in detail. Some of the studied features such as: type of trichome, ornamentation of the unspecialized cells of the adaxial surface and the ornamentation of subsidiary cells reinforce the results of BORHIDI et al., who segregated *Neomazaea tinifolia* from this genus. The author suggests future studies of *N. pungens*, as well.

Introduction

The genus *Neomazaea* was established by KRUG and URBAN on the basis of the species *Rondeletia* ? *phialanthoides* Griseb. In 1927, URBAN described the second species of this genus from Haiti and he named it *Neomazaea pungens*, but in the same year URBAN made a new combination of *Rondeletia tinifolia* Griseb. in *Neomazaea tinifolia* (Griseb.) Urb.

BORHIDI et al. (1980) based on the morphological and palynological characters of the Cuban endemic species segregated the species *Neomazaea tinifolia* as a new genus that they named *Acunaeanthus*.

VALES (1982) in a study on the wood anatomy of the Cuban species of this genus; can not find great differences due to the homogeneity of the secondary xylem of the Cuban endemic genera of the Rubiaceae which he investigated.

In this paper the leaf epidermal characters of taxonomic interest were studied in order to contribute to our understanding of affinities and delimitation of the genus, and to find additional arguments in favour or against of *Neomazaea* sensu URBAN (1927).

Material and methods

Herbarium material from the Institute of Botany of the Cuban Academy of Sciences (HAC) and from the National Herbarium of the United States of America (U. S.), Smithsonian Institution, were taken for this research.

Mature leaves were boiled in water and a portion of the middle was sampled and used for obtaining cuticular maceration. Macerations were obtained using FRANKLYN's method (equal volume of 20% hydrogen peroxide and concentrated glacial acetic acid at 60 °C overnight), and mounted in glycerin-jelly after staining in Sudan IV.

Scanning electron microscope (SEM) studies were carried out with the Cambridge instrument (Stereoscan S4-10) from the Smithsonian Institution using gold coated herbarium specimens.

Specific description

Neomazaea phialanthoides (Griseb.) Krug and Urban

Single unicellular hairs present on adaxial and abaxial surfaces. The base of the trichome is thickened and surrounded by a rosette of epidermal cells (Fig. 1). The hairs more numerous on the veins. Epidermal cells of adaxial surface pentagonal to hexagonal with straight to slightly curved anticlinal walls. Cuticular flanges pegged at cell corners. Periclinal walls of the unspecialized cells sunk with little protuberance or lowly papillate (Fig. 2). Epidermal cells of the abaxial surface similar to the adaxial's but recovered with small particle of wax (Fig. 3).

Cells overlying major veins more or less rectangular and arranged in rows. Stomata confined to abaxial surface, paracytic. Stomatal complex slightly sunk with reference to the epidermal cells, in average $46\text{ }\mu\text{m}$ long and $46\text{ }\mu\text{m}$ wide; guard cells pairs $35\text{ }\mu\text{m}$ long and $20.3\text{ }\mu\text{m}$ wide, the cells elongated reniform in paradermal view, without the so called T pieces at poles. Subsidiary cells show fine striations mostly perpendicular to the longitudinal axis of the complex (Fig. 4).

Material studied: HAC VALES 59 Loma Peluda, Cajalbana, Pinar del Río. 26: 12 (1974).

Neomazaea tinifolia (Griseb.) Urban*

Single unicellular hairs present on abaxial and adaxial surfaces, more numerous on the veins of the abaxial surface. The base of the trichome is thickened and surrounded by a rosette of epidermal cells. Unspecialized cells of adaxial surface pentagonal to hexagonal with straight to slightly curved anticlinal walls. With the light microscope cuticular flanges pegged at cell corners were observed. In paradermal view the periclinal walls show striate ornamentation (Fig. 5). Epidermal cells of the abaxial surface similar to the adaxial's (Fig. 6).

Cells overlying major veins more or less rectangular and arranged in rows with numerous hairs. Stomata confined to the abaxial surface, paracytic. Stomatal complex sunk in relation to the epidermal cells, in average $28\text{ }\mu\text{m}$ long and $30\text{ }\mu\text{m}$ wide; guard cells pairs $21\text{ }\mu\text{m}$ long and $15.6\text{ }\mu\text{m}$ wide, cells in paradermal view elongated reniform. Polar T pieces absent. Subsidiary cells with striation regularly parallel to the longitudinal axis (Fig. 7).

Material studied: HAC VALES 74. Las Pozas, Bahía Honda, Pinar del Río. 27: 11 (1974).

Neomazaea pungens Urban**

Single unicellular hairs present only on the abaxial surface, mainly on the veins. The base of the trichome is not well thickened and it is surrounded by a rosette of epidermal cells. Unspecialized cells of adaxial surface pentagonal to hexagonal with straight to slightly curved anticlinal walls. In paradermal view the periclinal walls show striate ornamentation (Fig. 8). Epidermal cells of the abaxial surface resemble to the adaxial's. Cells overlying major veins more or less rectangular and arranged in rows. Stomata restricted to the abaxial surface; paracytic (Fig. 9). Stomatal complex sunk in relation to the epidermal cells, averaging $35\text{ }\mu\text{m}$ long and $35\text{ }\mu\text{m}$ wide; guard cells pairs $28\text{ }\mu\text{m}$ long and $19.1\text{ }\mu\text{m}$ wide, cells elongated reniform. Polar T pieces absent. Subsidiary cells with striation in perpendicular direction to the longitudinal axis (Fig. 10).

* Actual valid name: *Acunaeanthus tinifolius* (Griseb.) Borhidi.

** Its actual valid name: *Suberanthus pungens* (Urb.) Borhidi.



Fig. 1. Adaxial surface of *N. phialanthoides*. $\times 300$

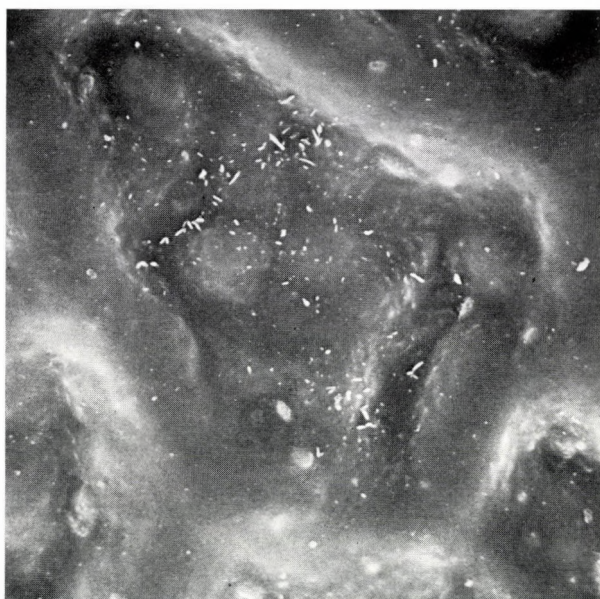


Fig. 2. Periclinal walls of the unspecialized cells of the adaxial surface in *N. phialanthoides*. $\times 1000$

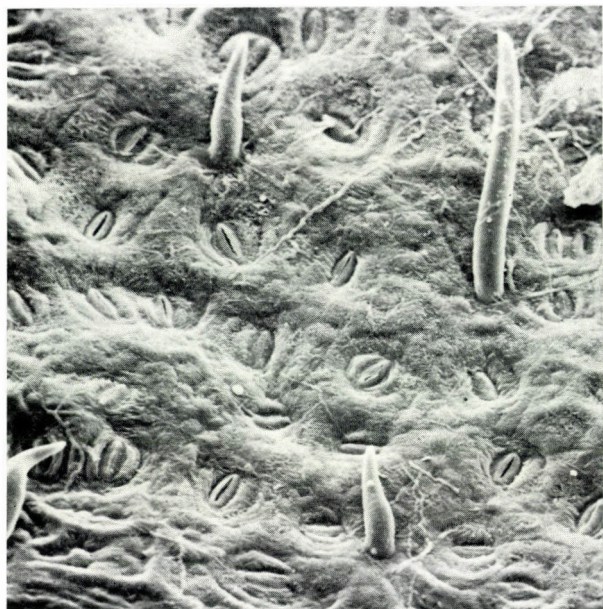


Fig. 3. Abaxial surface of *N. phialanthoides*. $\times 200$

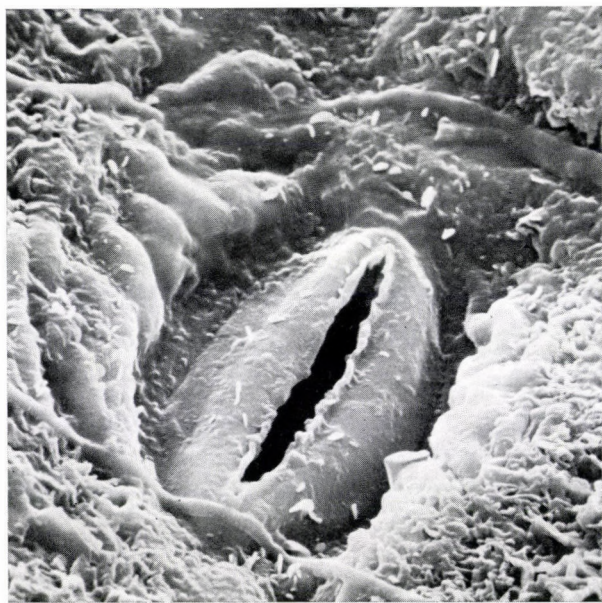


Fig. 4. Stomata with perpendicular ornamentation and waxy particles in *N. phialanthoides*. $\times 2000$

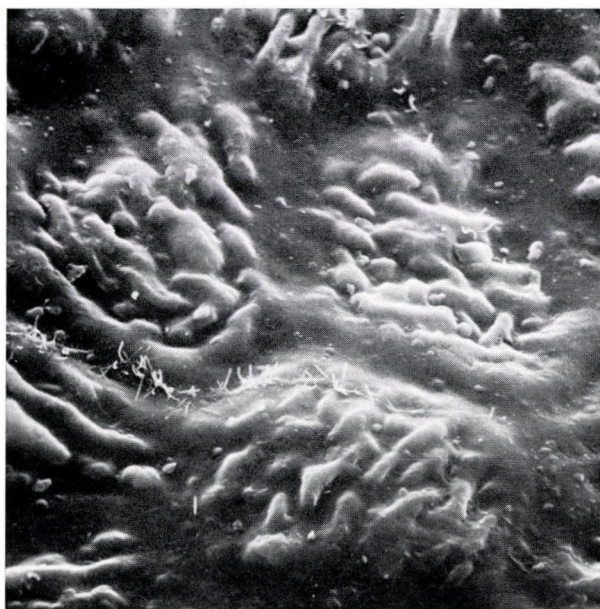


Fig. 5. *N. tinifolia*, adaxial surface. $\times 1000$

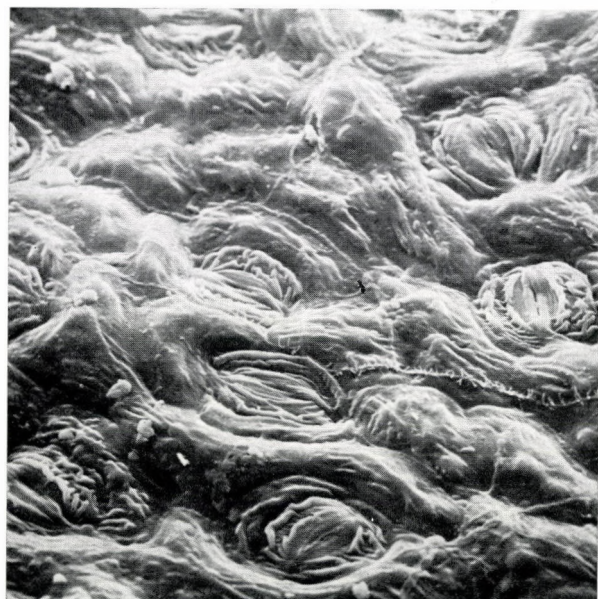


Fig. 6. *N. tinifolia*, abaxial surface tilt. $\times 35\ 500$

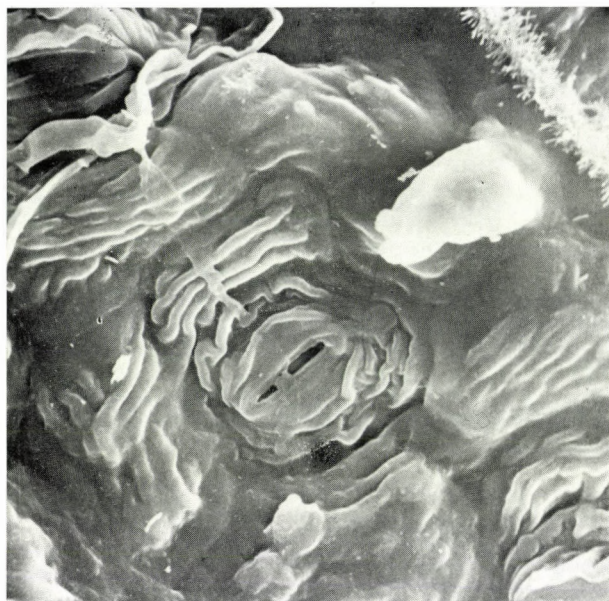


Fig. 7. *N. tinifolia*, parallel striations to the longitudinal axis of subsidiary cells. $\times 1000$

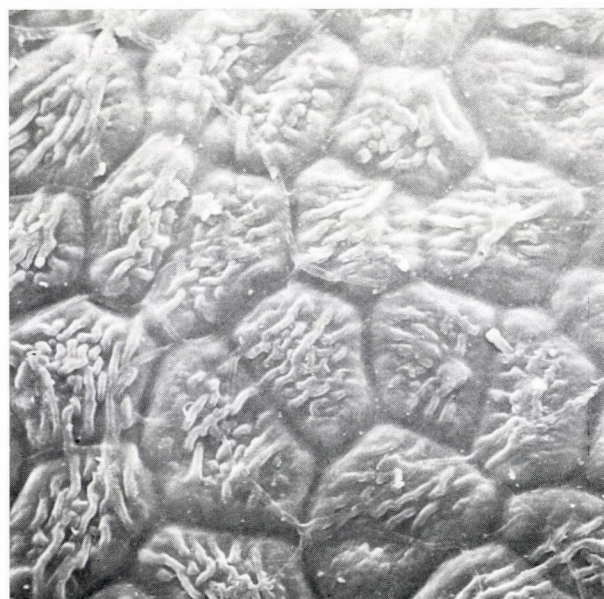


Fig. 8. *N. pungens*, adaxial surface. $\times 500$

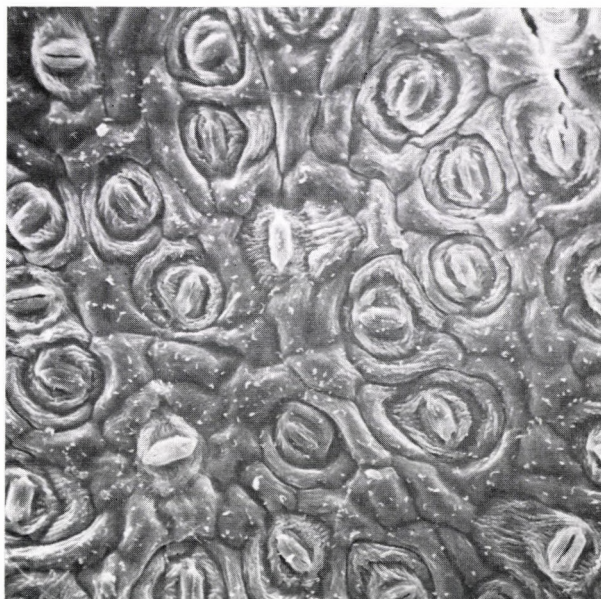


Fig. 9. *N. pungens*, abaxial surface. $\times 300$

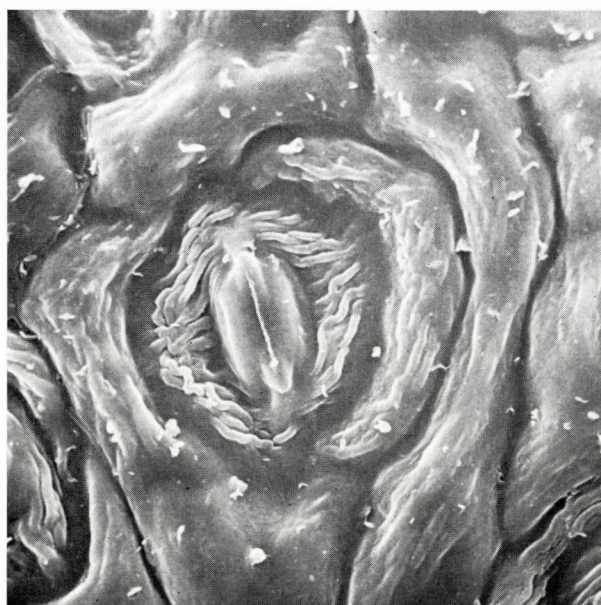


Fig. 10. *N. pungens*, perpendicular striations to the longitudinal axis of subsidiary cells. $\times 1000$

Material studied: EKMAN 4553. Presup' ile du Nord-Ouest, Port-de-Paix road to Anse-Rouge near Hab. St. Raimond. July 12 (1925). Isotype in US.

Survey of the leaf epidermal characters

Indumentum

Hairs are present in both surface in *Neomazaea phialanthoides* and *N. tinifolia* but *N. pungens* show the hairs only on the abaxial surface. The hairs are in all cases unicellular, surrounded by a rosette of epidermal cells. These trichomes in *Neomazaea pungens* are curved at the end and finer as in the other species (Figs 11 and 12). They are also numerous on the midrib and in the primary and secondary veins.

Unspecialized cells

The anticlinal walls are usually straight to slightly curved. With the light microscope they show minute peg-like protuberances in the cuticular flanges at the cell corners in *N. tinifolia* and *N. phialanthoides*, while in *N. pungens* these protuberances are present in all the cuticular flanges. Periclinal walls of the adaxial surface of *N. phialanthoides* are sunk and they are ornated with minute papillae. In *N. pungens* and *N. tinifolia* by other site, they show fine striations. Particles of wax were observed only in *N. phialanthoides*.

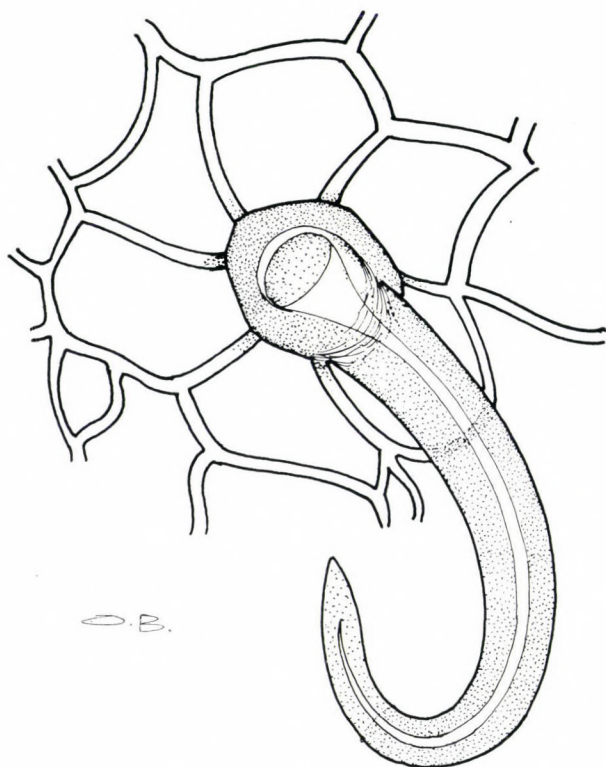


Fig. 11. Typical hairs for *N. pungens*

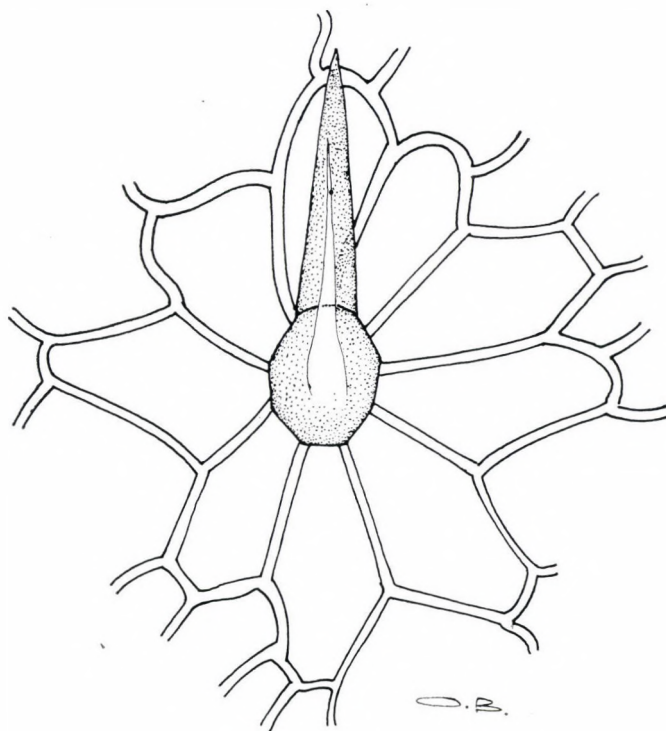


Fig. 12. Typical hairs for *N. tinifolia* and *N. phialanthoides*

Stomatal complex

The stomatal complex in the investigated taxa is paracytic and restricted to the abaxial surface. The subsidiary cells show special striation in the different species: In *N. phialanthoides* and *N. pungens* the striations are mostly perpendicular, but in *N. tinifolia* are parallel to the longitudinal axis of the complex.

Veins

The midrib and the complete network of minor veins show an arrangement of rectangular epidermal cells in rows. The studied species show the prominence of the midrib on the abaxial surface, but only in *N. pungens* was observed this feature on the adaxial surface.

Discussion

The features recorded in the descriptions are not all of the same diagnostic or taxonomic value. JANSEN and BAAS (1973) and others have stressed the restricted value of characters such as undulations of anticlinal walls, granulation of the cuticle and pitting of anticlinal flanges due to the great

variability of these characters below the species level. The only leaf characters considered to be of taxonomic value in discussing affinity or taxonomic boundaries within *Neomazaea* (sensu URBAN 1927) are the type of periclinal walls of the epidermal cells of the adaxial surface, type of hairs, the ornamentation of the subsidiary cells and the prominence of veins. The stomatal type is not considered here on account of only one type (paracytic) were observed in the studied taxa.

In the classification of a natural group, the use of a new set of characters should lead to a similar classification.

Analyses of epidermal features in *Neomazaea* (sensu URBAN 1927) tend to suggest that this classification have some problems, for example, *N. phialanthoides* show sunk peridermal walls with minute papillae in the unspecialized cells of upper epidermis, however *N. tinifolia* present striations in the periclinal walls of the epidermal cells. On the other hand, although the taxonomic value of the course of the striations of the subsidiary cells is not reported in the literature, it looks like of significance value for the delimitation of the Cuban species of *Neomazaea* due to in *N. phialanthoides* this feature has perpendicular direction while in *N. tinifolia* the ornamentation is parallel to the longitudinal axis of the stomatal complex. These results agree with BORHIDI et al. (1980) who segregated the species *N. tinifolia* as *Acunaeanthus tiniifolius* (Griseb.) Borhidi.

The presence of wax was only observed in *N. phialanthoides* with the SEM, it proves the potentialities and limitations of both, light microscope and the scanning electron microscope. For instance, characters such as anticlinal wall undulations, cuticular flanges pegged and arrangement of subsidiary cells are well demonstrated with light microscopy, but do not show up in SEM studies. The presence of wax particles is observed only with the SEM.

Table 1
Variation of some leaf anatomical characters in Neomazaea
(sensu URBAN 1927)

Species	Length of guard cells pairs (μm)	Width of guard cells pairs (μm)	Prominence of veins, adaxial	Prominence of veins, abaxial	Presence of wax	Hairs in adaxial surface	Hairs in abaxial surface	Periclinal walls of epidermal cells adaxial surface
<i>N. phialanthoides</i>	35	20.3	ms, 1, 2	m, 1, 2	×	×	×	sunk, minute, papillae
<i>N. tinifolia</i>	21	15.6	ms, 1s	m, 1	—	×	×	striate
<i>N. pungens</i>	28	19.1	ms, 1, 2	m, 1	—	—	×	striate

×, character present; 1, 2, primary and secondary veins; m, midrib; s, sunk

There are some differences in the leaf epidermal characters between *N. phialanthoides* and *Acunaeanthus tinifolius* in relations to *N. pungens*, for instance, the hairs type (curved at the end in *N. pungens*), difference in the ornamentation of the unspecialized epidermal cells of the abaxial surface, and the course of the subsidiary cell's ornamentation.

In conclusions, there are some reasons to suggest that *Neomazaea* may be really a monotypic endemic genus of West-Cuba, and that *Neomazaea pungens* must be revised because of the differences found in the leaf epidermal characters that they could be greater on a morphological study.

Table 1 summarizes the most important characters observed.

ACKNOWLEDGEMENTS

I wish to thank to the fellow members of the Department of Botany of the Smithsonian Institution, who prepared the material for the SEM and made all the technical work with this equipment. I wish to thank Mr. O. BABILONIA too, for the illustrations of the trichomes.

REFERENCES

- Borhidi, A., Járαι-Komlódi, M., Moncada, M. (1980): *Acunaeanthus*, a new genus of Rubiaceae. *Acta Bot. Acad. Sci. Hung.* **26**: 277-287.
- Jansen, W. T., Baas, P. (1973): Comparative leaf anatomy of *Kokoona* and *Lophopetalum* (Celastraceae). *Blumea* **21**: 153-178.
- Metcalf, C. R., Chalk, L. (1950): *Anatomy of the Dicotyledons*. Vol. 2. Clarendon, Oxford.
- Vales, M. A. (1982): Die Mikro- und Ultrastruktur einiger endemischen Rubiaceen-Arten. Dissertation zur Erlangung des Akademischen Grades Dr. rer. nat. Humboldt-Universität zu Berlin. 90 Seiten.

CHROMOSOMAL ABERRATIONS AND CHLOROPHYLL MUTATIONS INDUCED BY SOME PESTICIDES IN BARLEY

T. PUSZTAI

RESEARCH INSTITUTE FOR BOTANY, HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT, HUNGARY

(Received: 15 December 1982)

We studied four pesticides of various chemical structures and of different agricultural applications (Vitavax, Topsin-methyl 70 WP, Tedion V-18 and Furadan 10 G). Their mutagenic effects were tested both on cellular (chromosomal changes) and on organismic level (segregation of chlorophyll mutants) in barley, *Hordeum vulgare* L. The investigations of the pesticides in question was done in doses between 150 and 1000 ppm, depending on their toxicity.

Chromosomal aberrations were detected at metaphase. Furadan 10 G and Vitavax were almost equally effective: 14.12% and 12.65%, respectively. The strongest effect was detected in the case of Furadan 10 G (21.24%), at 300 ppm. Apart from one or two treatments, mutagenic effect of Tedion V-18 and Topsin-methyl 70 WP, had not proven to be significantly different from the control. In comparison to the effect of EI (5.06%), Furadan 10 G and Vitavax show a fourfold, while compared with the effect of γ -ray (11.4%), several pesticide treatments cause a twofold aberration frequency. Increase of pesticide concentration resulted in higher frequencies of chromosome aberration, e.g. the highest dose of Vitavax (1000 ppm) gives a ninefold effect as compared with the lowest one (400 ppm). Depending on the duration of treatments, mutagenicity of Furadan 10 G and of Vitavax, as well, increase on chromosomal and genic level alike. Similarly to EI treatment, both Furadan 10 G and Vitavax induce chromatide type aberrations. Regarding appearance of chlorophyll mutants in F_2 generation, Tedion V-18 appears to be the most effective: 1.88%. At Vitavax treatment the frequency of mutations was 0.79%. Topsin-methyl 70 WP and Furadan 10 G did not induce any mutations.

Parallel analyses of point and chromosome mutations gave different effects, for each chemical. Some of them (Tedion V-18) caused point mutations, others (Furadan 10 G) induced chromosome aberrations. It is advisable therefore, to use these two test systems jointly to obtain reliable mutagenic risk assessment.

Introduction

The application of pesticides in agricultural plant protection is an important factor for improving the level of productivity. Hence, their future use seems to be necessary and unavoidable in spite of their unwanted side effects.

Among these mutagen effects represent considerable risk to many organisms. Informations accumulate year by year on mutagenic effects of pesticides in various sorts of organisms — similar to the known effects of radiation and chemical mutagens (WUU and GRANT 1966; EPSTEIN and LEGATOR 1974; CURINNY and PILINSKAYA 1976). In Hungary, FÜREDI et al. investigated cytological effects of certain pesticides on different pea strains (1981). They found mainly mitotic but also some meiotic irregularities. Our previous work (PUSZTAI and VÉGH 1978) reports on chromosome irregularities, caused by almost every pesticides studied although to various degree.

The research of mutagenic activity of chemicals used in crop plant protection is one of the most important practical tasks of modern genetics, regarding the genetical security of human being and the whole biosphere. The inherited relation between mutagenic and carcinogenic effects of some chemicals (SOBELS 1977) further underlines the importance of such works.

To examine the mutagenic effect of pesticides, one has to use test objects on which the different kinds of mutations can be well registered. As for plants, recently the most convenient mutagenicity test is the analysis of chromosome aberrations (i.e. chromosome mutations). The screening of appearance of chlorophyll mutants (point mutations) is also a frequently used method in mutagenesis research.

Among higher plants, barley would be a proper object to test mutagenicity of environmental factors, as it is a diploid species, with low basic chromosome number and relatively large chromosome size, that makes possible the more or less exact detection of structural changes in chromosomes. Barley is a self-compatible plant therefore the recessive mutations may express themselves in the segregating generation (M_2).

In this paper we deal with the cytogenetic effects of four pesticides, in parallel with their effects in increasing the frequency of chlorophyll mutations.

Materials and methods

The four pesticides that we investigated for their mutagenic activity, are currently used in Hungary. All of them were provided by the Plant Protection and Agrochemistry Service of the Ministry of Agriculture and Food Production.

The trade names of these pesticides, as well as the chemical names and structural formats of their ingredients are listed in Table 1. Vitavax and Topsin-methyl 70 WP are applied as fungicides, Furadan 10 G and Tedion V-18 are used as insecticides.

The quantity of the chemical in each treatment was calculated for the amount of active ingredient, dissolved in acetone, diluted with distilled water afterwards (up to the concentration demanded). The effect of one per cent acetone solution was preexperimentally checked: it did not differ from that of water control. The concentrations of chemicals for the treatments were chosen in proportion to the previously obtained LC_{50} values treated with freshly prepared solutions of various concentrations, pH = 7 for 6 and 12 h, respectively. Distilled water as negative control, 0.1% ethylenimine (EI) solution and 10 krad γ -ray (^{60}Co , 384 rad/min) were used as positive control.

The barley, *Hordeum vulgare* L. ($2n = 14$) grains were obtained from the Agricultural Research Institute of the Hungarian Academy of Sciences and labelled by them as the Mv-43 strains.

Criteria for the genetical effectiveness of the chemicals tested were: the induction of chromosomal changes at the cell level, and the appearance of chlorophyll mutants in the second generation.

Cytological test

The treatments of the grains were run in 4–4 parallels and their total results are presented here. Altogether 200 grains were germinated in each experiments. 50 dry seeds were placed into 200 ml pesticide solution. Then the seeds were washed in running water and placed on moist filter paper in Petri dishes kept in 24 °C thermostat for 26–36 h. 3–5 mm long root tips were used for cytological investigation. Metaphase cells of the root tip meristeme were studied. The fixation, staining and the squash preparation were done according to a previously published method of us (PUSZTAI–GILYAROVSCAYA 1973).

Chlorophyll mutation test

Outdoor experiments were run in the experimental garden (Budapest) of the Botanical Institute of the Hungarian Academy of Sciences. Grains were treated for 12 h as given above. In each experiment 800 seeds were treated in four parallels thereafter they were sown into

Table 1

Trade names, active ingredients, composition and chemical structure of the compounds tested

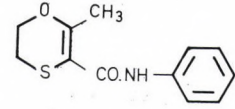
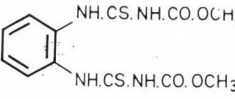
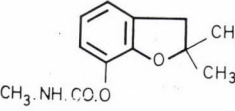
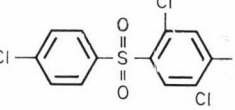
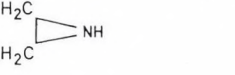
Trade name	Active ingredient	Chemical name	Structural formula
Vitavax	Carboxin (75%)	2,3-dihydro-6-methyl-5-phenyl-carbamoyl-1 4-oxathiin	
Topsin-methyl 70 WP	Thiophanatemethyl (70%)	1,2-bis(3-metoxycarbonyl-2-thiouredio) benzene	
Furadan 10 G	Carbofuran (10%)	2,3-dihydro-2,2-dimethyl-benzofuran-7-yl N-methylcarbamate	
Tedion V-18	Tetradifon (8%)	4-chlorophenyl 2,4,5-trichlorophenyl sulphone ethylenimine	 

Table 2

Frequency and distribution of types of chromosome aberrations induced by pesticides in barley root tips

Pesticides	Treatment time, h	Concentration, ppm	Total No. of cells	Total No. of abnormal cells	Abnormal cells										abnormal cells	mean for each time period
					Distribution								Percentage			
					chromatide type				chromosome type							
					fragment	isochromatide deletions	interchanges	chromatide ring	fragment	dot deletion	ring	dicentric	Others			
Vitavax	6	400	1143	41	12	7	13	2	1		2	3	1	3.59 ± 0.55***	8.70	
		800	921	102	53	14	21	4			4	3	3	11.07 ± 1.03***		
		1000	705	98	59	10	19	1	1		1	3	2	13.90 ± 1.30***		
	12	400	884	61	18	11	19	3	2	1	2	3	2	6.90 ± 0.85***	12.65	
		800	798	116	57	15	27	5	1	1	2	4	4	14.54 ± 1.25***		
		1000	539	104	55	15	22	3	1			2	6	19.29 ± 1.70***		
Topsin-methyl 70 WP	6	200	684	13	3	2	5		2				1	1.90 ± 0.52	2.85	
		400	892	34	14	9	5		3		3			3.81 ± 0.64**		
		600	601	15	4	5	4		1	1				2.50 ± 0.64		
	12	200	793	24	7	9	3		3					3.03 ± 0.61**	3.09	
		400	838	31	14	9	5			1	2			3.70 ± 0.65***		
		600	632	15	5	2	6		2					2.37 ± 0.61		
Furadan 10 G	6	150	1034	25	7	3	7	2	3		1		2	2.42 ± 0.48*	12.74	
		300	973	189	93	30	45	5	8	1	4	2	1	19.42 ± 1.27***		
		450	893	167	102	22	30	5	4		2		2	18.70 ± 1.38***		
	12	150	989	67	17	10	24	6	3		2	5		6.77 ± 0.80***	14.12	
		300	838	178	101	20	34	4	7		3	2	7	21.24 ± 1.41***		
		450	630	102	56	16	20	2	2	1		2	3	16.19 ± 1.47***		

Tedion V-18	6	200	1038	20	5	4	7	2		2	1.93 ± 0.43	1.91
		400	727	15	3	8	2	2	1		2.06 ± 0.55	
		300	691	13	5	1	5			2	1.88 ± 0.48	
	12	200	632	11	4	2	3	2		1	1.74 ± 0.39	2.01
		400	821	19	11		6	2			2.31 ± 0.58	
		600	483	9	5	4					1.86 ± 0.72	
EI	0.1 %		1422	72	20	12	27	4	2	3	4	5.06 ± 0.58
γ -rays	10 krad		1038	114	3	4			19	29	59	11.40 ± 0.38
H ₂ O			1221	15	4	7	2			1	1	1.23 ± 0.32

* Significant at 0.05 level of probability

** Significant at 0.01 level of probability

*** Significant at 0.001 level of probability

micro plots. The area of each plot was 1 m² and there were 200 grains sown onto them. The data obtained from four parallels are summarized in Table 3.

All pesticide treatments were supplemented by negative and positive controls.

The appearance of chlorophyll mutants was detected in M₂ generation, therefore the spikes of each M₁ plant had been separately planted into sand in greenhouse and germinated on 10–12 °C. The frequency of chlorophyll mutants was calculated for 100 M₂ seedlings, and 100 M₁ spikes, respectively.

Experimental results

1. Cytological effects of the pesticides

The observations of cytological effects of pesticides were supplemented with suitable positive and negative controls. As positive control, we applied γ -ray and EI treatments, as negative control the grains were germinated in distilled water.

The investigation of the pesticides in question, was done in various doses, depending on their toxicity. For the cytogenetic analysis, the highest concentration was equal with the subtoxic level, where the root tip mitotic index is 50 per cent of that of the control. The other concentration values were established as equal dilutions of the subtoxic concentration.

The cytological results of effect are shown in Table 2. It can be seen that γ -ray caused 11.4%, the EI treatment induced 5.06% chromosome aberrations. The majority of pesticides examined also induced chromosome structural changes, although to various degrees.

The mutagenic effect of Tedion V-18 had not proven to be significantly different from the control, though we detected some increase in the frequency of alterations. As for Topsin-methyl 70 WP, in 6 hours long treatment the effect of only one dose (400 ppm) appears to be significant, while the 12 hrs treatment significantly increased the aberrations at both 200 and 400 ppm doses. Furadan 10 G and Vitavax exhibited nearly identical effectiveness. The strongest effect was detected in the case of Furadan 10 G: 21.24%. Among Vitavax treatments, the percentage of alterations shows a greater and smaller increasing at each of 12 h treatments compared to the 6 h long treatment. In the case of both Furadan 10 G and Vitavax the frequency of chromosome aberrations increases with the duration of treatments. Increase of pesticide concentration resulted higher frequencies of chromosome aberrations, e.g. the highest dose of Vitavax shows a ninefold effect as compared with the lowest one. On the base of cytological analyses, dose effect curve of Furadan 10 G appears to be irregular at the highest dose (450 ppm) in 6 and 12 h treatment a decrease of aberration frequency can be found.

In comparison to EI treatment, Furadan 10 G and Vitavax caused a twofold higher frequency of aberrations (not taking into account the 6 h long Vitavax treatment). Finally, in comparison to the effect of γ -ray, we got similar results.

In Table 2, the types of aberrations are summarized. The γ -ray treatment (as positive control) induced predominantly reunion-type damages (dicentric, ring) and less frequently breaks. Out of the aberrations, 84% were reunion and 18% fragment. The other positive control, EI treatment resulted mostly in chromatid type aberrations. Out of the changes observed 60% were chromatid-translocation type and 14% fragment. The spontaneous aberrations found in the water control were chromatid type, 60% being translocational and 26% fragment.

The spectrum of the aberrations observed after herbicide treatments shows that Furadan 10 G and Vitavax induce some chromosome- and many chromatid-type aberrations (Table 2).

Higher concentrations resulted in the increase of the proportion of chromatid-type aberrations and, at the same time, a decrease of that of chromosome type. For example,

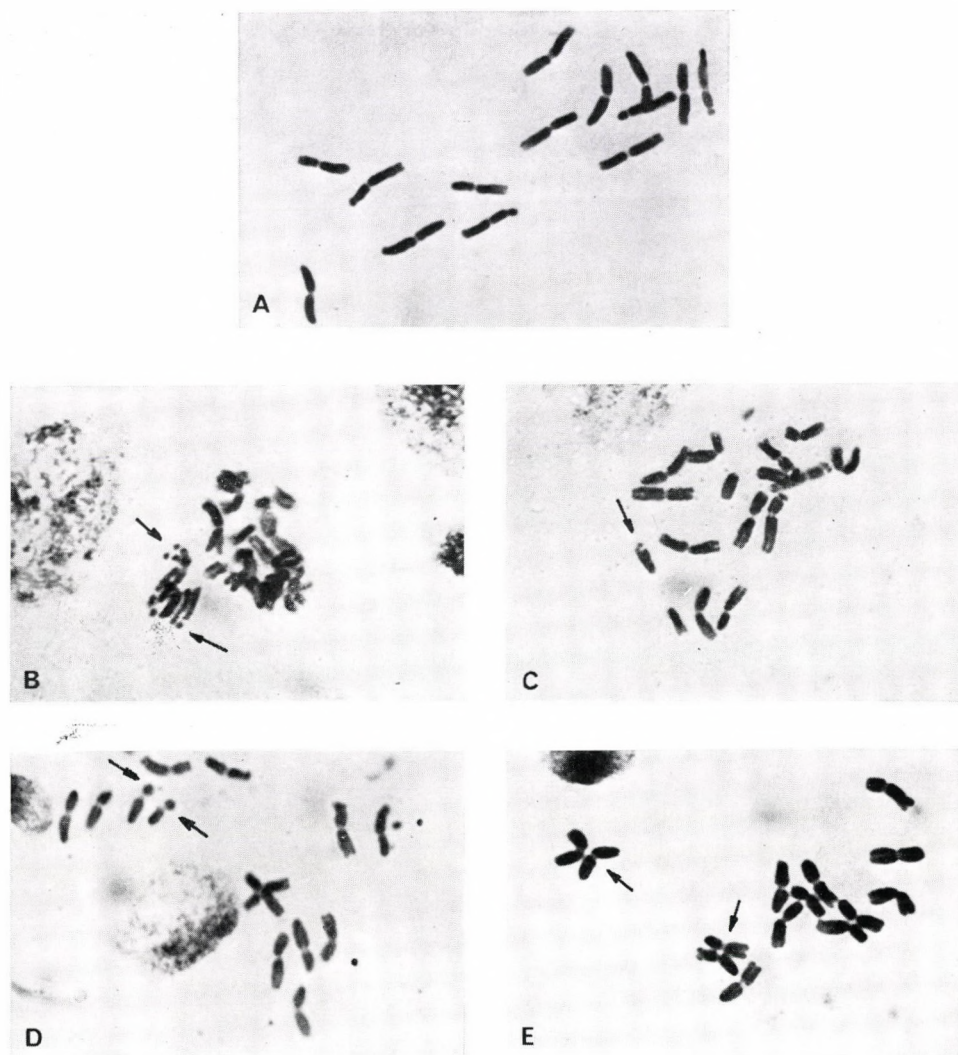


Plate 1

Chromatid-type aberrations observed in *Hordeum* root tip cells. A: Normal chromosome. B: Chromatid breaks (fragment). C: Chromatid acentric ring. D: Isochromatid break with sister chromatid reunion. E: Chromatid interchange

Furadan 10 G 150 ppm caused 25% fragmentation and 60% translocation. At 450 ppm, however, the corresponding data are 56% and 34%, respectively.

Types of aberrations are shown in Plates 1, 2.

2. Chlorophyll mutants

The other marker for genetic effect of the chemicals examined was the appearance of chlorophyll mutants in the second generation.

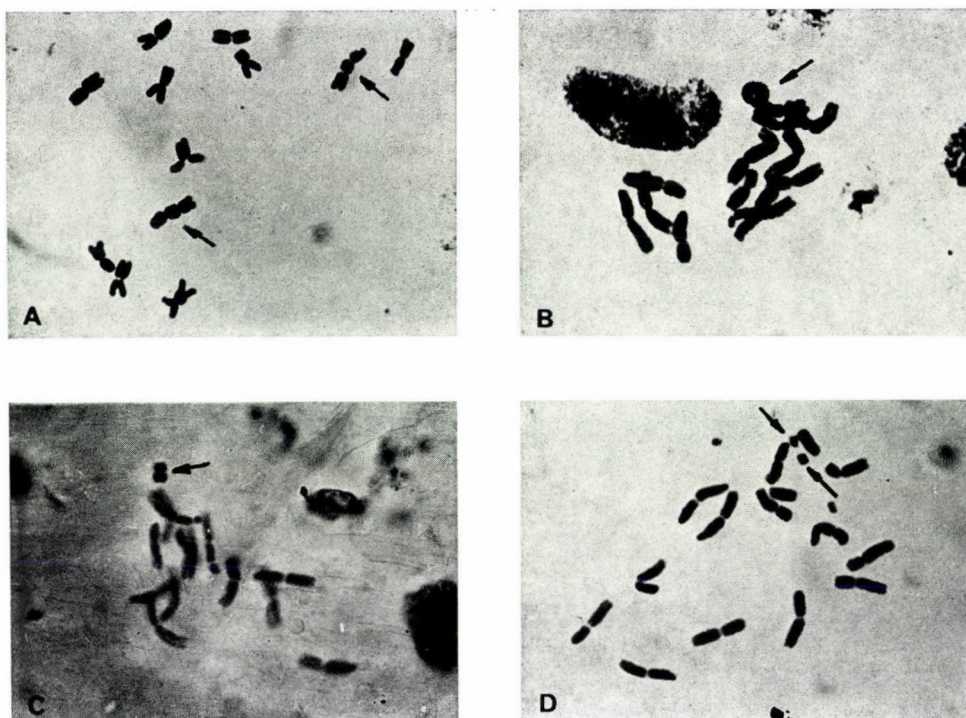


Plate 2

Chromosome-type aberrations observed in *Hordeum* root tip cells. A: Dicentric aberrations (asymmetrical interchange). B: Centric ring. C: Acentric ring. D: Acentric fragment

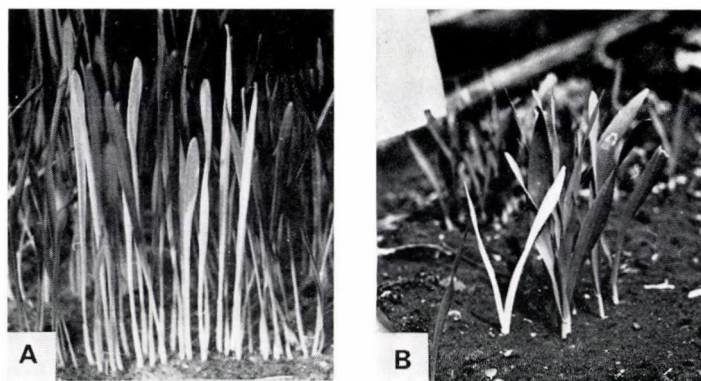


Plate 3

Albino mutants in M_2 generation of *Hordeum vulgare*. A: EI, 0.1%. B: Tedium V-18, 400 ppm

Table 3
Chlorophyll mutation frequency in M_2 generation

Pesticides	Concentration, ppm	Number of M_1 spikes		Number of M_2 seedlings		Mutation frequency per 100		Mean for each pesticide
		scored	mutants	scored	mutants	M_1 spikes	M_2 seedlings	
Vitavax	400	592	—	10 656	—	—	—	
	800	678	31	9 848	42	4.57	0.42	0.35
	1000	418	29	6 688	53	6.93	0.79	
Topsin-methyl 70 WP	200	508	—	8 636	—	—	—	
	400	535	4	7 490	4	0.74	0.05	0.02
	600	581	—	7 553	—	—	—	
Furadan 10 G	150	698	1	11 866	2	—	—	0.016
	300	621	—	9 315	—	—	—	—
	450	556	—	6 672	—	—	—	—
Tedion V-18	200	607	16	7 284	19	2.63	0.26	
	400	583	61	6 996	132	10.46	1.88	1.01
	600	592	36	7 672	71	6.08	0.92	
EI	0.1%	621	137	11 799	449	22.06	3.80	
γ -rays		672	26	13 440	59	3.87	0.44	
H ₂ O		631	—	13 251	—	—	—	

As the mutants were mainly of albino type (90%; Plate 3) all chlorophyll mutants are given without any further specification. The frequency of chlorophyll mutants are calculated for 100 M_2 seedlings and 100 M_1 spikes respectively (Table 3). In the negative control there was no chlorophyll mutant at all.

In our experiments, Tedion V-18 seems to be the strongest inducer of chlorophyll mutation. The effect of Vitavax is less pronounced, while the other two pesticides, Topsin-methyl 70 WP and Furadan 10 G virtually did not induced any mutations.

The increase of concentration of Tedion V-18 and Vitavax, usually resulted in similar effect on the frequency of chlorophyll mutations.

Discussion

Genetic effects of pesticides were studied at both cell and organismic levels. The former was estimated by the investigation of the frequency of chromosome aberrations, while the latter was judged from that of chlorophyll mutants. The cytological test system reveals the chromosome mutations, the chlorophyll test detects the point mutations in the gene system controlling pigment synthesis (NYBON 1955).

Using the cytological methods one can directly get data for the frequency of chromosomal changes. At the same time this method is quick and cheap for the evaluation of induced mutagenesis in plants.

In barley, cytogenetic observations often refer to anaphase changes only. Metaphase analysis we used in our experiment shows a considerably more detailed and accurate picture making the assessment of aberrations more reliable both quantitatively and qualitatively.

In the pesticide treatments, the mutagenic effect was cytologically detected as breakage and reunion-type aberrations. As a result of chromosome or chromatid breakage, dicentric chromosomes, isolocus breaks with reunion or translocation could be observed in the microscopic preparations. In our experiments the γ -ray irradiation caused more reunion as fragments, while the other positive control, EI induced reunions and fragments almost in the same amount. As compared with the effect of pesticides, the latter induce mostly chromatid-type aberrations. It means that the structural changes in chromosomes occur in the double stranded stage (S and G₂ phases of the cell cycle).

In the spectrum, there can be found a low number of chromosome-type aberrations that refer to changes during G₁ (before DNA synthesis). These are consistent with DUBININ's data (1968) for several alkylating agents.

There are some published data regarding mutagenic features of Furadan 10 G and of Vitavax and show similar results as ours. NAHLA et al. (1980) and SOLIMIN (1980) published the fungicid effect of Vitavax. SINGH et al. (1979) and SATNAIAH et al. (1974) documented the cytogenetic effect of Furadan 10 G on barley and onion, respectively.

Depending on the duration of treatment, the mutagenicity of Furadan 10 G and Vitavax (both on chromosomal and genic level) can be explained by the different length of time for the penetration into the seed, thus affecting more cells.

In GUSTAFSSON's and McKEY's opinion (1948), chlorophyll mutants in barley are comparable to recessive lethals of *Drosophila*. This way, they can be used as a mutation test.

The frequency of albino-type chlorophyll mutants in natural conditions is about 10^{-4} (SHEVTSOV 1969). In our experiments Tedion V-18 induced more than a hundred-fold increase of this frequency. Although the effectiveness of Vitavax was somewhat weaker, one should take into consideration its more widespread application as a potent fungicide in our agricultural praxis.

Parallel analysis of point and chromosome mutations gives an opportunity for a more complete presentation of genetic effects of various mutagenic chemicals. Comparing the number of chromosome aberrations and that of chlorophyll mutations, we conclude that Tedion V-18 insecticide is very powerful in inducing chlorophyll mutations but hardly effective in making chromosome aberrations. On the other hand, Furadan 10 G produced only chromo-

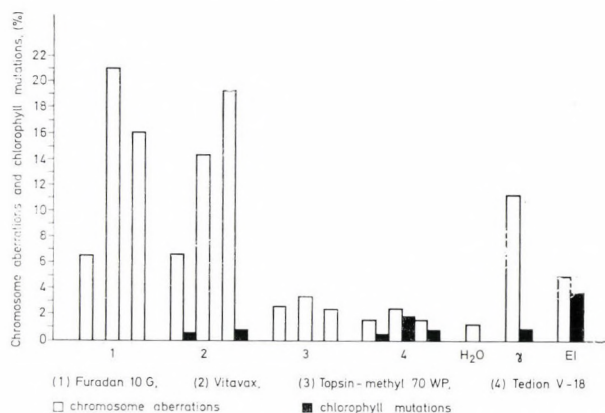


Fig. 1. Chromosome aberrations and chlorophyll mutations induced by some pesticides in barley

some abnormalities. Vitavax caused both chlorophyll and chromosome mutations, with a tendency towards the latter (Fig. 1).

This way, one can happen to classify a point mutation-inducing agent as non-mutagenetic, in the absence of suitable cytological information. It is advisable therefore, to use these two test systems jointly to obtain reliable mutagenic risk assessment.

ACKNOWLEDGEMENT

The author thanks Mrs. V. RUMPLER for her skilful technical assistance.

REFERENCES

- Al-Najjar, N. R., Soliman, A. S. (1980): Cytological effects of fungicides, I. Mitotic effects of Vitavax-200 and Dithane S-60 on wheat and two related species. *Cytologia* **45**: 163–168.
- Curinny, A. I., Pilinskaya, M. A. (1976): *Investigation of Pesticides as Environmental Mutagens*. (In Russian.) Naukova Dumka, Kiev.
- Dubinina, L. G., Dubinin, N. P. (1968): Novelty in effects of alkylating agents for chromosome mutation. (In Russian.) *Genetika* **4**: N. 2, 5.
- Epstein, S. S., Legator, M. S. (1971): *The mutagenicity of pesticides*. The MIT Press, Cambridge, 220 p.
- Füredi, J., Badwi, M., Bedő, Z. (1981): Frequency of irregular cell division in *Pisum sativum* in response to different rates of herbicide application carried out over several generations. *Acta Agron. Acad. Sci. Hung.* **30**: 19–31.
- Giljarovskaya-Pusztai, T. T. (1973): Metaphase method for analysis of chromosome rearrangements in barley. *Cytol. i. Genet.* **4**: 369–370.
- Gustafsson, A., McKey, J. (1948): The genetical effect of mustard gas substances and neutrons. *Hereditas* **34**: 371.
- Nybohm, N. (1955): The pigment characteristic of chlorophyll mutations in barley. *Hereditas* **41**: 483.
- Pusztai, T., Végh, A. (1978): Mutagenic effects of pesticides, I. Cytological effects on some substituted urea herbicides in barley. *Acta Bot. Acad. Sci. Hung.* **24**: 327–342.
- Sathaiah, V., Appaiah, S. G., Venkat, R. P. (1974): Cytological effects of 2,3-dihydro-2,2-dimethyl-7-benzofuranyl methyl-carbomate "Carbofuran". *Curr. Sci. (India)* **43**: N.2. 53–54.

- Shevtsov O. M. (1969): The effect of mutagens on the mutation frequency in barley. (In Russian.) *Genetika* **4**: N.3. 33–42.
- Singh, B. D. et al. (1979): Effect of insecticides on germination, early growth and cytogenetic behavior of barley (*Hordeum vulgare*). *Env. and Exp. Bot.* **19**: 127–132.
- Sobels, F. H. (1977): Some problems associated with the testing for environmental metagens and a perspective for studies in "comparative mutagenesis". *Mutat. Res.* **46**: N.4. 245–260.
- Soliman, A. S., Al-Najjar, N. R. (1980): Cytological effects of fungicides, II. Chromosomal aberrations induced by Vitavax-200 and Dithane S-60 in meiotic cells. *Cytologia* **45**: 169–175.

CHROMOSOMAL AND ISOENZYME VARIABILITY IN CALLUS TISSUE CULTURES OF ALBINO MUTANT OF *NICOTIANA SYLVESTRIS*

L. SZILÁGYI¹ and A. H. NAGY²

¹ RESEARCH INSTITUTE FOR BOTANY, HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT, HUNGARY

² DEPARTMENT OF GENETICS, EÖTVÖS LORÁND UNIVERSITY, BUDAPEST, HUNGARY

(Received: 15 September 1982)

Spontaneous formation of diploids and polyploids and aneuploids was observed in callus cultures which originated from a stable haploid albino *N. sylvestris* plant. The karyotypic changes were probably induced by interaction of explant with culture condition. The diploid form is discussed as probable optimum condition for these callus cultures. Analysis of specific isoenzyme and protein patterns in callus lines suggested that quantitative and qualitative differences had been produced by variability of the chromosome number.

Introduction

Genetic and biochemical studies generally assume that somatic tissues are genetically uniform. However, in vitro studies of morphogenesis force one to recognize the karyotypic variability of callus cultures derived from the same plant. The in vitro accumulation of chromosome number variability appears to be a genetic instability of cell and tissue cultures. According to cytological studies, polyploid and aneuploid cells accumulate in prolonged callus cultures. For example, the haploid chromosome number was only maintained during the first passages in stem-derived tissue cultures of *Anthirinum majus*. In prolonged cultures, diploid and tetraploid cells appeared (MELCHERS and BERGMAN 1958). In tissue cultures of *Pelargonium*, the frequency of polyploid cells increased during the course of cultivation (BENNICI 1974). Another chromosomal change which occurs frequently in in vitro cultures is aneuploidy. In general, aneuploidy is to be expected in mature tissues (HEINZ et al. 1969).

Extensive aneuploidy was produced in the first phases of callus induction in the primary explant of stem pith of *Nicotiana tabacum*, cultured on a medium supplemented with indole acetic acid (NAYLOR et al. 1954).

Chromosome structural changes of different types are not rare in plant tissue and cell cultures, and these changes also originate during in vitro culture (KAO et al. 1970).

The analysis of isoenzymes was previously shown to be an effective tool for characterization of genetic differences in population of species (ALLARD et al. 1970, BABBEL and WAIN 1977). A direct correlation has been observed between chromosome dose and corresponding isoenzyme activity in most isoenzyme systems in tomato species (FOBES 1977). Significant differences in mean chromosome number and isoenzyme expression were demonstrated in callus cultures of *Hordeum vulgare* × *Hordeum jubatum* interspecific hybrid (ORTON 1980).

In our earlier paper, it was demonstrated, that the haploid albino plant of *Nicotiana sylvestris* had a significantly higher chromosome number stability when compared to wild type. The majority of cells from the albino plants remained permanently haploid (SZILÁGYI and NAGY 1978). The present study examines the occurrence and degree of chromosomal variability of *Nicotiana sylvestris* tissue cultures originated from a haploid albino plant. Specific

isoenzyme patterns and soluble protein composition of crude extract from calli are presented to demonstrate the connection between chromosomal variability and isoenzyme expression in tissue culture of same source plant.

Material and methods

Callus tissues derived from a haploid albino *N. sylvestris* plant were used in this study. All tissues were maintained on the medium described by LINSMAIER and SKOOG (1965) enriched with 10 mg/l thiamine, 0.1 mg/l kinetin and 0.1 mg/l 2,4 dichlorophenoxyacetic acid. The cultures were kept at 25 °C in dark.

The following citological technique was employed: fresh pieces of callus tissue were fixed in Farmer solution stained with acetocarmine. An NFpK 2 microscope with an MF Zeiss camera was used to make microphotographs.

Crude extracts of calli were prepared for electrophoresis and electrofocusing.

Tissue samples were extracted with three volume of 0.04 M Tris-HCl buffer pH 7.8, containing 5 mM dithiothreitol, 5 mM 2-mercaptoethanol, 0.01 M $MgCl_2$, 0.25 mM EDTA and 0.4 M sucrose. The extracts were subsequently centrifuged for 20 min at $5000 \times g$ at 2–5 °C and the supernatant was used for electrophoresis. The protein content of samples was measured according to the method of BRADFORD (1976).

Aliquots with equal protein concentrations were separated on 6% polyacrylamide gels (DAVIS 1964) and stained for enzyme-specific reactions. The reaction mixture for glucose-6-phosphate dehydrogenase (G6PD) contained 0.05 M Tris-HCl buffer pH 7.5, 4 mM $MgCl_2$, 2 mM glucose-6-phosphate, 0.15 mM NADP⁺, 0.2 mg/ml p-nitrotetrazolium blue, 0.05 mg/ml phenazine methosulphate. Leucine aminopeptidase (LAP) isoenzymes were stained according to BREWBAKER et al. (1968). Esterases were separated on an 8.5% polyacrylamide gel, which was prepared by modification of the DAVIS system. Components of the gel buffer were 48.0 ml 1 N HCl, 6.55 g TRIS, and 0.46 ml TEMED in 100 ml stock solution. Electrode buffer contained 5.52 g diethylbarbituric acid and 1.0 g TRIS in 1000 ml, pH 7.0. Esterases were stained according to SCANDALIOS (1969). Peroxidase isoenzymes were extracted with 0.1 M TRIS-HCl pH 8.0 which contained 0.1% cysteine hydrochloride and 0.1% ascorbic acid. After centrifugation the supernatant was separated on a vertical gradient (7–15%) polyacrylamide gel and the peroxidases were then visualized by the method of McDONALD et al. (1972). Soluble proteins from the tissues were analysed by isoelectric focusing in a vertical cylindrical polyacrylamide gel using the 2.5% (v/v) ampholine 3.5–10 pH range (WRIGLEY 1968). Proteins were stained with Coomassie brilliant blue R-250.

Experimental results

Callus tissues were induced from leaves of the haploid albino mutant of *Nicotiana sylvestris*. Nine subcalli were cultivated in a steady non-regenerated form (X_1 , X_2 , X_3 , X_5 , X_7 , X_{11} , X_{12} , X_{13} and X_{19}).

The characteristic variability of karyotypes is shown in Fig. 1. Haploid ($n = 12$), diploid ($2n = 24$), triploid ($2n = 36$) and tetraploid ($2n = 48$) cells are presented in the pictures which originated from different tissue cultures. Cells of the different subcalli which originated from the haploid plant have chromosome numbers from 12 to 48 (Table 1). Except for the X_7 subcalli, the frequency of diploid cells (with 24 number) was much higher, than the other cell types. Several haploid cells were only found in X_1 , X_2 and X_{11} subcalli. A high number of tetraploid cells (with 48 chromosomes) was demonstrated in the markedly slow growing X_7 line.

Specific isoenzyme and protein patterns from the crude extracts of callus lines show characteristic differences. One major protein band (in marked position in Fig. 2) was absent from the X_3 and X_{12} lines.

Very low leucine aminopeptidase activity was detected in extracts from X_3 subcallus line. One slow moving isoform of X_{11} culture and one fast moving isoform of X_{12} were absent

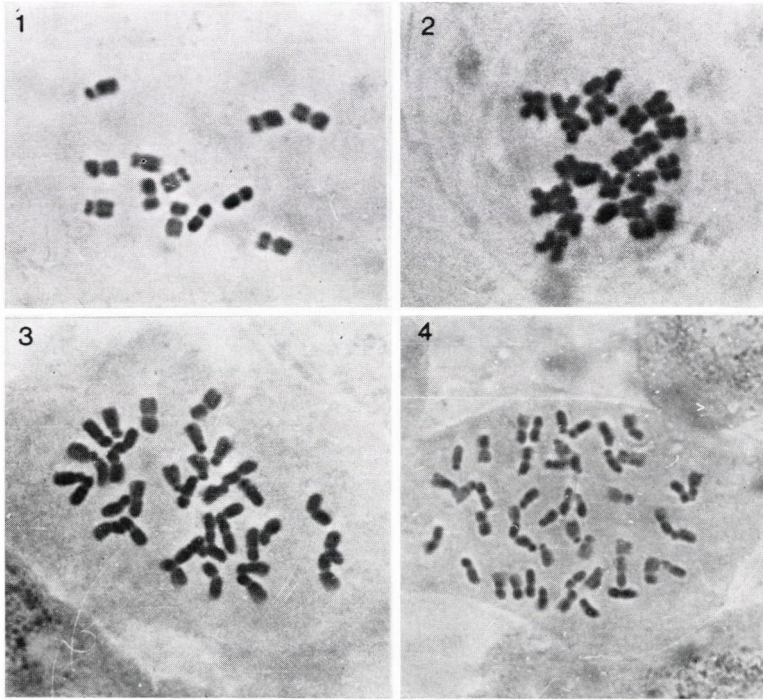


Fig. 1. Somatic chromosomes of callus lines originated from *Nicotiana sylvestris* albino mutant plant. (1. $n = 12$, 2. $2n = 24$, 3. $3n = 36$, 4. $4n = 48$)

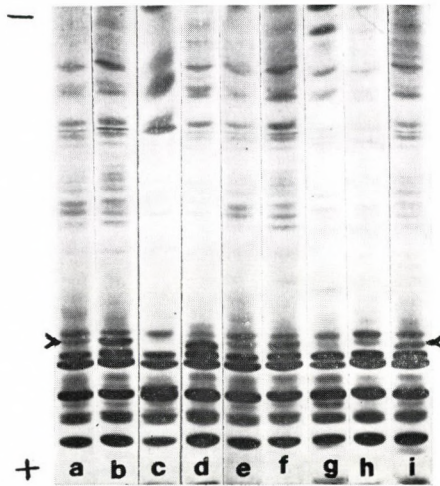


Fig. 2. Soluble protein composition of callus lines originated from *Nicotiana sylvestris* albino mutant plant. Samples were separated by polyacrylamide gel isoelectric focusing in the presence of ampholine pH 3.5–10 (a = X_1 , b = X_2 , c = X_3 , d = X_5 , e = X_7 , f = X_{11} , g = X_{12} , h = X_{13} , i = X_{19} lines)

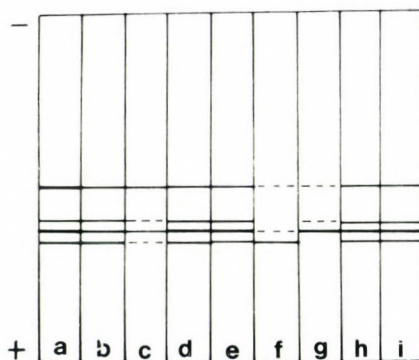


Fig. 3. Zymogram for leucine-aminopeptidase (LAP) of callus lines originated *Nicotiana sylvestris* albino mutant plant (a-i see Fig. 2)

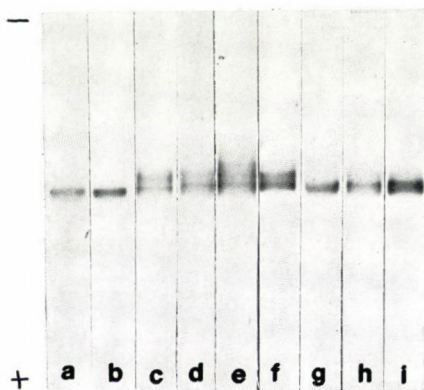


Fig. 4. Glucose-6-phosphate dehydrogenase isoenzymes of the extracts of callus lines originated from *Nicotiana sylvestris* albino mutant plant (a-i see Fig. 2)

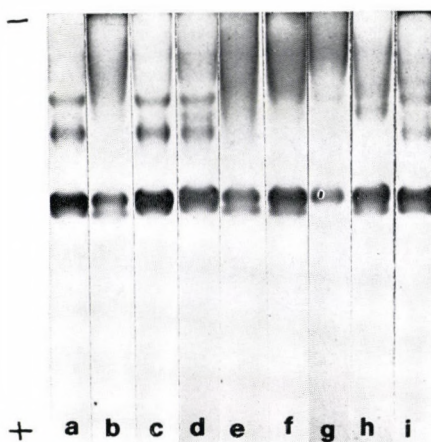


Fig. 5. Esterase isoenzymes in extracts of callus lines originated from *Nicotiana sylvestris* albino mutant plant (a-i see Fig. 2)

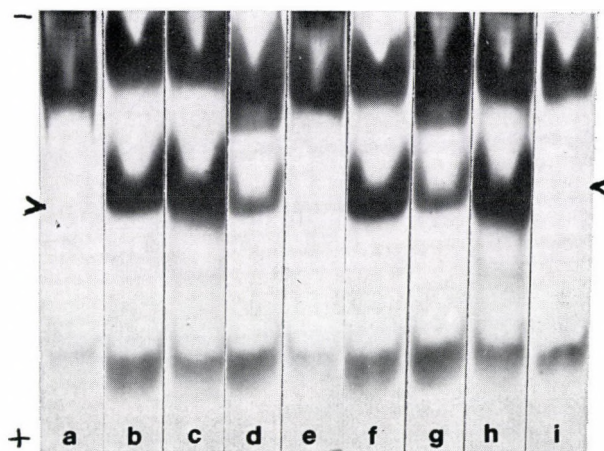


Fig. 6. Peroxidase isoenzymes in extracts of callus lines originated from *Nicotiana sylvestris* albino mutant plant (a-i see Fig. 2)

(Fig. 3). Three types of G6PD isoenzyme pattern were found, which contained one, two or three active bands.

Triple-banded types were shown in the extracts of X_7 and X_{11} subcallus lines. Two active isoforms were demonstrated in cultures of X_3 , X_5 , X_{13} and X_{19} line. One-banded patterns were specific of X_1 , X_2 and X_{12} subcalli (Fig. 4).

The slow moving esterases of various subcalli were completely missing, but most of the variability was connected with quantitative differences in band intensity. Fast-moving esterases were better separated and four one-banded (X_1 , X_3 , X_5 , X_{12}) and five double-banded (X_2 , X_7 , X_{11} , X_{13} , X_{19}) forms were detected (Fig. 5).

One type of peroxidase isoenzyme (in marked position of Fig. 6) was undetectable in X_{19} lines and it was present in very low activity in X_1 , X_7 subcalli.

Discussion

Callus cultures of *Nicotiana sylvestris* which were formed from a stable haploid albino plant showed differences in chromosome number and of isoenzyme and protein patterns. The differences were manifested in formation of diploid, polyploid and aneuploid cells and also by qualitative and quantitative differences in the isoenzyme and protein composition of crude tissue extracts.

Variability of chromosome number is well known from the literature concerning cell culture, tissue and regenerated forms of *Nicotiana* species and hybrids. Greatly variable chromosome numbers have been published regarding somatic hybrid plants of *N. knightiana* and *N. tabacum* (MALIGA et al. 1978). YANG (1965) and SMITH (1968) suggested that in sexual hybrids of the different *Nicotiana* species, the hybridity and high chromosome number alone provides a satisfactory explanation for the observed chromosome

Table 1

*Variability of chromosome number in callus tissue culture,
obtained from albino mutant of Nicotiana sylvestris*

Callus line	2n	12	15	17	18	24	36	48
	number of cells							
X ₁		7				169		3
X ₂		1				172	1	1
X ₃					1	29		9
X ₅			1	2	3	126	3	
X ₇						14		96
X ₁₁		3	6	6		55		1
X ₁₂					8	84		3
X ₁₃					4	30		5
X ₁₉						7		3
Total		11	7	8	16	686	4	121
853								
%		1.28	0.82	0.93	1.87	80.42	0.46	14.18

instability. Recently, spontaneous polyploidy and aneuploidy were observed in callus cultures of *Hordeum vulgare*, *Hordeum jubatum*, and their inter-specific hybrid (ORTON 1980). The observation of variable chromosome number in tissue cultures of these species suggested that genome interactions were not responsible for chromosomal variability in hybrid tissue cultures. Chromosomal variability was spontaneously generated as a consequence of the interaction of explant with culture condition. The degree and extent of polyploidy in an in vitro culture tend to increase progressively with increasing age of the primary explant or callus or under particular hormonal regimes (MELCHERS and BERGMANN 1958, MURASHIGE, NAKANO 1967, BENNICI et al. 1971). Two phenomena have been observed to produce polyploidy in proliferating cell and tissue cultures. It has been shown that some cells may undergo one or two additional endo-reduplication cycles during culture (BENNICI et al. 1968, DEVREUX et al. 1971). An important mechanism of polyploidisation in vitro appears to be restitution nucleus formation due to spindle failure and chromosome lagging at anaphase (BAYLISS 1973).

Aneuploidy also originates during in vitro culture, as clearly shown by a progressive increase in frequency and extent of aneuploidy with increasing age of the cultures of different plant species (TORREY 1967, MURASHIGE, NAKANO 1965, 1967). An important observation is the dependence of degree

and extent of aneuploidy on the organ from which explants are taken (SHIMADA 1971, YAMADA et al. 1967).

Non-random selection of particular chromosomes was observed by SINGH et al. (1972) in *Vicia hajastana* cultured in vitro.

This study demonstrated the attenuation of haploidy in callus cultures originated from a stable haploid albino plant of *Nicotiana sylvestris*. Cytological analysis suggests a higher stability of diploid state, however the presence of polyploid and aneuploid cells demonstrates a karyological instability in the tissue cultures. This instability did not originate from the parent plants, it was generated as a consequence of culture condition. The variability of chromosome number was found to be associated with variability of protein and isoenzyme patterns. Increased activities of isoenzymes of esterase and aspartate aminotransferase were proved by ORTON (1980) in *Hordeum* autotetraploids, as compared to diploids. In our experiments quantitative variability was found in the activity of leucine aminopeptidase and esterase isoenzymes. This difference suggests a chromosome dose dependent isoenzyme expression in cultures. The absence of some soluble protein molecules, peroxidase, esterase, glucose-6-phosphate dehydrogenase and leucine aminopeptidase isoforms may be connected with differential gene expression or non-random chromosome elimination in aneuploid cell lines originated from a non-variable haploid plant.

ACKNOWLEDGEMENT

We thank Prof. G. VIDA for critical reading of the manuscript, and M. BAKÓ, K. BACHOFFER and M. LICHTENBERGER for the technical assistance.

REFERENCES

- Allard, R. W., Kahler, A. L., Weir, B. S. (1970): Isoenzyme polymorphisms in barley populations. In: Nilan, R. A. (ed.): *Barley Genetics II*. Washington State University, Pullman, Wash., pp. 1-13.
- Babbel, G. R., Wain, R. P. (1977): Genetic structure of *Hordeum jubatum* L. I. Outcrossing rates and heterozygosity levels. *Can. J. Genet. Cytol.* **19**: 143-152.
- Bayliss, M. W. (1973): Origin of chromosome number variation in cultured plant cells. *Nature* **246**: 529-530.
- Bennici, A. (1974): Cytological analysis of roots, shoots and plant regenerated from suspension and solid in vitro cultures of haploid *Pelargonium*. *Z. Pflanzenzücht.* **72**: 199-205.
- Bennici, A., Buiatti, M., D'Amato, F. (1968): Nuclear conditions in haploid *Pelargonium* in vivo and in vitro. *Chromosoma* **24**: 194-201.
- Bennici, A., Buiatti, M., D'Amato, F., Pagliai, M. (1971): Nuclear behaviour in *Haplopappus gracilis* callus grown in vitro on different culture media. In: *Colloq. Intern.* No. **193**, *Les Cultures de Tissus de Plantes* pp. 245-250. Paris: C. N. R. S.
- Bradford, M. M. (1976): A rapid and sensitive method for the quantitations of microgram quantities of protein utilizing the principle of protein-dye binding. *Anal. Biochem.* **72**: 248-254.
- Brewbaker, J. L., Upadhyia, M. D., Makinen, Y., MacDonald, T. (1968): Isoenzyme polymorphism in flowering plants III. Gel electrophoretic methods and applications. *Physiol. Plantarum* **21**: 930-940.
- Fobes, J. F. (1977): *Trisomic analysis of isozymic loci in tomato species: Segregation and dosage effects*. Ph.D. Thesis, University of California, Davis, C. A.

- Heinz, D. J., Mee, G. W. P. (1969): Chromosome numbers of some *Saccharum* species hybrids and their cell suspension cultures. *Am. J. Botany* **56**: 450–456.
- Kao, K. N., Miller, R. A., Gamborg, O. L., Harvey, B. L. (1970): Variations in chromosome number and structure in plant cells grown in suspension culture. *Can. J. Gen. Cytol.* **12**: 297–301.
- Linsmaier, E. M., Skoog, F. (1965): Organic growth factor requirements of tobacco tissue cultures. *Physiol. Plantarum* **18**: 100–127.
- MacDonald, T., Smith, H. H. (1972): Variation associated with an *Aegilops umbellulata* chromosome segment incorporated in wheat. II. Peroxidase and leucine aminopeptidase isoenzymes. *Genetics* **72**: 77–86.
- Maliga, P., Kiss, Zs. R., Nagy, A. H., Lázár, G. (1978): Genetic instability in somatic hybrids of *Nicotiana tabacum* and *Nicotiana knightiana*. *Mol. Gen. Genet.* **163**: 145–151.
- Melchers, G., Bergmann, L. (1958): Untersuchungen an Kulturen von haploiden Geweben von *Antirrhinum majus*. *Ber. Deut. Botan. Ges.* **71**: 459–463.
- Murashige, T., Nakano, R. (1965): Morphogenetic behavior of tobacco tissue cultures and implication of plant senescence. *Am. J. Botany* **52**: 819–827.
- Murashige, T., Nakano, R. (1967): Chromosome complement as a determinant of the morphogenetic potential of tobacco cells. *Am. J. Botany* **54**: 963–970.
- Naylor, J., Sander, G., Skoog, F. (1954): Mitosis and cell enlargement without cell division in excised tobacco pith tissue. *Physiol. Plantarum* **7**: 25–29.
- Orton, T. J. (1980): Chromosomal variability in tissue cultures and regenerated plants of *Hordeum*. *Theor. Appl. Genet.* **56**: 101–112.
- Scandalios, J. G. (1969): Genetic control of multiple molecular forms of enzymes in plants: A review. *Biochem. Genetics* **3**: 37–79.
- Shimada, T. (1971): Chromosome constitution of tobacco and wheat callus cells. *Jap. J. Genet.* **46**: 235–241.
- Singh, B. D., Harvey, B. L., Kao, K. N., Miller, R. A. (1972): Selection pressure in cell population of *Vicia hajastana* cultured in vitro. *Can. J. Gen. Cytol.* **14**: 65–70.
- Smith, H. H. (1968): Recent cytogenetic studies in the genus *Nicotiana*. *Advanc. Genet.* **14**: 1–43.
- Szilágyi, L., Nagy, A. H. (1977): Comparative analysis of green and spontaneous albino mutant lines of *Nicotiana sylvestris* Speg. et Comes. *Acta Bot. Acad. Sci. Hung.* **23**: 219–227.
- Torrey, J. G. (1967): Morphogenesis in relation to chromosome constitution in long term plant tissue cultures. *Physiol. Plantarum* **20**: 265–275.
- Yamada, Y., Tanaka, K., Takahashi, E. (1967): Callus induction in rice, *Oryza sativa*. *Proc. Jap. Acad.* **43**: 156–159.
- Yang, S. I. (1965): Numerical chromosome instability in *Nicotiana* hybrids. II. Intraplant variation. *Can. J. Genet. Cytol.* **7**: 112–119.
- Wrightley, C. (1968): Gel electrofocusing. A technique for analyzing multiple protein samples by isoelectric focusing. *Sci. Tools.* **15**: 17–23.

MORFOLOGIA DEL POLEN DE LAS ESPECIES CUBANAS DE GYMNOSPERMAS

L. STUCHLICK¹ y MILAGROS MONCADA²

¹INSTITUTO DE BOTÁNICA, ACADEMIA DE CIENCIAS DE POLONIA, CRACOVIA, POLONIA

²INSTITUTO DE BOTÁNICA, ACADEMIA DE CIENCIAS DE CUBA, LA HABANA, CUBA

(Recibido: 1 Noviembre 1982)

Pollen morphology of 13 species belonging to the Gymnosperms represented in Cuba corresponding to the genera: *Zamia*, *Microcycas*, *Podocarpus*, *Pinus* and *Juniperus* is described. In the genus *Podocarpus* two types of pollen grains can be distinguished, that suggest the existence of not more than two species or species group in Cuba. Also in the Cuban species of the genus *Pinus* are found some differences in size as in the pattern of the reticulum.

Introducción

Con esta publicación comenzamos varios trabajos que conciernen a la morfología de polen de diferentes plantas cubanas, con el objeto de viabilizar estudios que se desarrollarán teniendo como base la palinología. En el presente trabajo se describen los tipos de granos de polen en las Gimnospermas cubanas. El conocimiento de éstas y otras estructuras permitirá asentar las bases para los estudios geobotánicos, taxonómicos, paleobotánicos y geológicos.

En la actualidad, en lo que respecta a los Gimnospermas, no hay una uniformidad de criterios en relación a algunos taxa, un ejemplo de ello es el caso del género *Zamia* en Cuba, y en general para Las Antillas, debido esto, probablemente a la variabilidad de las especies. Por lo que, al realizar esta investigación hemos decidido confeccionarla teniendo en cuenta el problema de la nomenclatura para las especies cubanas.

En los años recientes, los trabajos acerca de la historia de la vegetación y especialmente aquellos que conciernen al Cuaternario y Terciario se van incrementando cada vez más en muchos países, en el nuestro prácticamente no existen, pues la falta de un estudio de la morfología de los granos de polen de las Gimnospermas y Angiospermas, así como, el de las esporas de helechos, ha imposibilitado este tipo de investigación. Sin embargo, es bien conocida la importancia de las Gimnospermas en los estudios de paleobotánica, paleoecología y geología. Estas investigaciones se continuarán con otros grupos de plantas de la flora de Cuba, con el fin de realizar un atlas de polen.

Materiales y metodos

Se utilizó material de polen fresco colectado en el campo, así como, el extraído del Herbario del Instituto de Botánica de la Academia de Ciencias de Cuba (HAC). Las muestras fueron procesadas según la técnica de ERDTMAN (1943, 1966), de Acetolisis y Clorinación, y montadas en gelatina-glicerina con parafina alrededor. La terminología usada principalmente ha sido la de ERDTMAN (1966). En algunos casos se utilizó la terminología introducida

por FAEGRI et IVERSEN (1964). La observación de la morfología del grano de polen se realizó mediante un microscopio óptico, Amplival Carl Zeiss con ocular de PK 10 \times y objetivo plano acromático 40 \times , inmersión 100 \times . Las mediciones acerca de la estructura fina de las membranas del grano de polen se hicieron con el objetivo de inmersión y el tornillo micrométrico MOB 15 \times . Las fotografías con el scanning se realizaron con material previamente acetolizado, empleando las técnicas usuales para este tipo de observación.

Relación de las especies investigadas

Cycadaceae

1. *Zamia kickxii* Miq., Cuba, 1930; LEÓN 14278, HAC
2. *Zamia angustifolia* Jacq., Cuba, 1864–66; WRIGHT 597, HAC
3. *Zamia latifoliolata* Preneloup, Cuba, 1948; ALAIN 682 A, HAC
4. *Zamia pygmaea* Sims., Cuba, 1950; LEÓN 1703, HAC
5. *Microcycas calocoma* (Miq.) A. DC., Cuba, 1974; MONCADA 163, HAC

Taxaceae

6. *Podocarpus ekmanii* Urban, Cuba, 1950; ALAIN y ACUÑA 5645, HAC
7. *Podocarpus angustifolius* Griseb., Cuba, 1956; ACUÑA 20291, HAC
8. *Podocarpus aristulatus* Parl., Cuba, 1864–66; WRIGHT 1402, HAC

Pinaceae

9. *Pinus tropicalis* Morelet, Cuba, 1955; KILLIP 44562, HAC
10. *Pinus cubensis* Griseb., Cuba, 1946; CLEMENTE 5160, HAC
11. *Pinus caribaea* Morelet, Cuba, 1930; LEÓN 14752, HAC
12. *Pinus maestrensis* Bisse, Cuba, 1955; L. FIGUEIRAS 2111, HAC

Cupressaceae

13. *Juniperus lucayana* Britton, Cuba, 1974; MONCADA 1280, HAC

Descripciones de los granos de polen

Cycadaceae

Zamia kickxii. — Granos de polen bilaterales, monocolpados. Oblongos a globosos de 26–35 μm de largo. Exina 1.6–2.4 μm de grosor; elementos de la columela imperceptibles. Nexina menos de 0.5 μm . Sexina 1.3–2.1 μm de grosor. La superficie aparentemente con una escultura muy fina (LO), los elementos \pm imperceptibles (Lám. I, 1–4).

Zamia angustifolia. — Granos de polen bilaterales, monocolpados. Elípticos a globosos de 29–37 μm de largo. Los colpos con membranas presentando ondulaciones irregulares. Exina cerca de 2.2 μm de grosor; elementos de columela imperceptibles. Nexina menos de 0.5 μm de grosor. Sexina 1.6–1.9 μm de grosor. La superficie con muy fina escultura (LO?), los elementos \pm imperceptibles (Lám. I, 5–7).

Zamia latifoliolata. — Granos de polen bilaterales, monocolpados. Elípticos a globosos de 26–36 μm de largo. Exina cerca de 2.0 μm de grosor, elementos de la columela imperceptibles. Nexina muy fina cerca de 0.5 μm de grosor. Sexina 1.3–1.6 μm de grosor. La superficie con muy fina escultura (LO?), los elementos \pm imperceptibles (Lám. I, 8–11).

Zamia pygmaea. — Granos de polen bilaterales, monocolpados. Oblongos a globosos de 29–35 μm de largo. Exina 1.9–2.9 μm de grosor; elementos de la columela imperceptibles. Nexina menos de 0.5 μm de grosor. Sexina 1.5–2.5 μm de grosor. La superficie del grano de polen con muy fina escultura. La estructura como LO. Los elementos menos de 0.5 μm de ancho (Lám. II, 1–4).

Microcycas calocoma. — Granos de polen bilaterales, monocolpados. Oblongos a globosos de 22–33 μm de largo. Los colpos mas bien gruesos. Membrana alrededor de los colpos ligeramente ondulada. Exina 2.3–3.3 μm de grosor; elementos de la columela imperceptibles. Nexina muy fina menos de 0.5 μm de grosor. La superficie del tectum con diminutas ondulaciones (Lám. II, 5–10).

Taxaceae

Podocarpus angustifolius. — Granos de polen bilaterales, bivesiculados, ocasionalmente 3 vesiculados hasta sinvesiculados de 50–69 μm de ancho, compuestos del cuerpo central y dos vesículas, en ocasiones unidas hasta formar una vesícula alrededor del cuerpo.

El cuerpo central oblató de 29–33 \times 33–40 μm de diámetro, tectado, con un leptoma en la parte distal. Exina más gruesa en la parte proximal desde 1.7–2.5 μm de grosor, en la parte distal desde 0.9–1.4 μm . La superficie más o menos lisa hasta con irregularmente LO modelo. Tectum apoyado sobre las columelas muy finas de menos de 0.5 μm de diámetro. La sexina en el cuerpo ligeramente ondulada, especialmente la parte proximal. Nexina de 0.5 μm de grosor. Las vesículas circulares hasta ovales de 25–43 \times 13–24 μm de diámetro. La exina en las vesículas de 1 μm de grosor con una escultura semejante a un retículo, con los muros más o menos fragmentados de 1 μm de grosor. Las lúminas desde 1–9 μm de diámetro (Lám. III, 1–10).

Podocarpus aristulatus. — Granos de polen bilaterales, bivesiculados, de 43–50 μm de ancho, compuestos del cuerpo central y dos vesículas. El cuerpo central oblató de 21–25 \times 27–33 μm de diámetro, tectado, con un leptoma en la parte distal.

Exina más gruesa en la parte proximal de 2.1 μm de grosor, en la parte distal hasta 1.2 μm . Sexina distintamente ondulada. Tectum apoyado sobre las columelas muy finas de menos de 0.5 μm de diámetro. Nexina de 0.5 μm de grosor. Vesículas regularmente ovales de 29–31 \times 16–22 μm de diámetro. Exina con las vesículas muy finas menos de 1 μm de grosor, con una escultura semejante a un retículo, con muros muy finos e irregularmente fragmentados (Lám. IV, 1–5).

Podocarpus ekmanii. — Granos de polen bilaterales, bivesiculados de 56–78 μm de ancho, compuestos de un cuerpo central y dos vesículas. El cuerpo central oblató hasta circular desde 20–32 \times 32–37 μm de diámetro, tectado, con un leptoma en la parte distal. Exina más gruesa en la parte proximal hasta 2.9 μm , en la parte distal hasta 0.9 μm . Sexina distintamente ondulada. Tectum apoyado sobre columelas muy finas de menos de 0.5 μm de diámetro. Nexina de 0.5 μm de grosor. Las vesículas más grandes que en las especies anteriores de 31.49 \times 17–40 μm de diámetro, usualmente el doble que el cuerpo. Exina en las vesículas muy finas, menos de 1 μm de grosor con una escultura parecida a un retículo, con los muros alargados e irregularmente interrumpidos. Las lúminas desde 1–10 μm de diámetro (Láms. IV–V, 6–10).

Pinaceae

Pinus tropicalis. — Granos de polen bilaterales, bivesiculados, de 65–86 μm de largo, compuestos del cuerpo central y dos vesículas. El cuerpo central generalmente oblató de $32\text{--}64 \times 34\text{--}50$ μm de diámetro, tectado. Exina considerablemente más gruesa en la parte proximal hasta 2.8 μm en la cima o casquete, adelgazándose hacia la parte distal hasta 1.5 μm . Nexina de 0.5 μm de grosor. La superficie del cuerpo central verrucosa hacia la parte dorsal y escabrosa en la parte ventral. Tectum apoyado sobre columelas pequeñas. Vesículas globosas hasta obladas de $30\text{--}50 \times 19\text{--}31$ μm . La superficie de las vesículas intra-reticuladas, el diámetro de las lúminas de 1–6 μm . Los muros de 0.5–1 μm de ancho (Lám. VI, 1–4).

Pinus cubensis. — Granos de polen bilaterales, bivesiculados de 77–85 μm de largo, compuestos del cuerpo central y dos vesículas. El cuerpo central oblató de $38\text{--}62 \times 36\text{--}42$ μm de diámetro, tectado. Exina más gruesa en la parte proximal, hasta 3.5 μm en la cima o casquete, adelgazándose hacia la parte distal hasta 2.3 μm . Nexina más o menos de 1 μm de grosor. La superficie del cuerpo central y tectum como en *Pinus tropicalis*. Las vesículas globulares hasta ovaladas de $36\text{--}50 \times 32\text{--}36$ μm de diámetro. La superficie de las vesículas intra-reticuladas, el diámetro de las lúminas de 1–6 μm . Los muros de 0.6 μm de ancho (Lám. VI, 5–6).

Pinus caribaea. — Granos de polen bilaterales, bivesiculados, de 62–87 μm de largo, compuestos del cuerpo central y dos vesículas. El cuerpo central oblató de $54\text{--}65 \times 27\text{--}52$ μm de diámetro, tectado. Exina más gruesa en la parte proximal hasta 2 μm en la cima o casquete, adelgazándose hacia la parte distal hasta 1 μm . Nexina menos de 0.5 μm de grosor. La superficie del cuerpo central y tectum como en *P. tropicalis*. Vesículas globulares hasta obladas de $27\text{--}50 \times 22\text{--}31$ μm de diámetro. Superficie de las vesículas intra-reticuladas. Las lúminas de 1–4 μm de diámetro. Los muros de 0.5 μm de ancho (Lám. VII, 1–5).

Pinus maestrensis. — Granos de polen bilaterales, bivesiculados, de 69–100 μm de largo, compuestos del cuerpo central y dos vesículas. El cuerpo central oblató de $46\text{--}73 \times 42\text{--}60$ μm de diámetro, tectado. Exina más gruesa en la parte proximal hasta 4 μm en la cima o casquete, adelgazándose hacia la parte distal hasta 1.7 μm . Nexina más o menos de 0.7 μm de grosor. La superficie del cuerpo central y tectum como en las especies anteriores. Vesículas globulares hasta ovales de $42\text{--}62 \times 34\text{--}42$ μm de diámetro. Superficie de las vesículas intra-reticulada. Las lúminas de 1–5 μm de diámetro. Los muros de 0.7 μm de ancho (Lám. VIII, 1–4).

Cupressaceae

Juniperus lucayana. — Granos de polen inaperturados hasta monoleptados (microleptados), intectados, esferoidales hasta ovalados de 19–31 μm de diámetro. Exina 1 μm de grosor. Sexina más gruesa que la nexina. La superficie de la exina psilada con algunas escrobículas (Lám. VII, 6–8).

Discusion y conclusiones

El estudio palinológico de las gimnospermas de Cuba ha aportado los siguientes resultados:

1. No existen grandes diferencias entre los granos de polen de las cuatro especies del género *Zamia*. Los granos de polen pertenecen a un tipo morfológico. Solamente los elementos de la superficie de los granos de *Zamia pygmaea* y *Z. kickxii* son un poco distintos que los de las otras especies.

En la Flora de Cuba, LEÓN (1946), existen actualmente ocho especies del género *Zamia*. En el Suplemento de la Flora de Cuba, ALAIN (1969) menciona cuatro especies de las reportadas por SCHUSTER en 1932. READ (1967), en un estudio acerca de las Cycadaceae de Las Antillas y La Florida ha tratado de separar las especies cubanas, de las citadas por LEÓN (1946). Por esta razón hemos estudiado la morfología de polen del género de las especies que encontramos en el Herbario con buen material polinífero.

2. *Microcycas calocoma* pertenece a un solo tipo de grano de polen que se diferencia del tipo de *Zamia* por presentar la exina más gruesa y ondulación en la membrana de los colpos.

3. Dentro de los granos de polen de *Podocarpus* se pueden distinguir dos tipos. Uno pertenece a *Podocarpus angustifolius* y *P. aristulatus*, el segundo tipo corresponde a *Podocarpus ekmanii*. Esto puede sugerir que solamente se encuentran en Cuba dos especies o dos grupos de especies del género. STASZKIEWICZ (comunicación personal) confirmó la posibilidad de esta división. ERDTMAN (1965), estudió la morfología de los granos de polen de dos especies cubanas de *Podocarpus*, de modo que, nuestros resultados concuerdan con los hallados por él. El tipo *angustifolius* representa polen cuyo cuerpo es más o menos del mismo tamaño que las vesículas; el tipo *ekmanii* tiene el cuerpo más pequeño en comparación con las vesículas, ellas son \pm dos veces el tamaño del cuerpo.

Por otra parte, solamente en el tipo *angustifolius* se pueden encontrar granos de polen bivesiculados hasta sin vesiculados.

Sólo en el tipo *ekmanii* se encontró un cuerpo esferoidal; el otro tipo tiene siempre cuerpo oblato hasta oblato-esferoidal. El tipo *ekmanii* tiene la exina de la parte distal más fina (menos de 1 μm) que el tipo *angustifolius* (hasta 1.9 μm).

Existen también algunos caracteres diferentes dentro de las especies del tipo *angustifolius*. La exina en *Podocarpus angustifolius* es ligeramente ondulada, en las especies de *P. aristulatus* la exina es distintamente ondulada.

4. La morfología de los granos de polen de las especies cubanas del género *Pinus* es muy uniforme y pertenece a un solo tipo. No obstante, hay ciertos caracteres como el tamaño, la forma del cuerpo y las diferencias en las dimensiones del retículo que permiten distinguir las especies estudiadas.

P. cubensis y *P. maestrensis* presentan granos de polen con el cuerpo central siempre oblato hasta oblato-esferoidales, con las vesículas mas bien grandes. *P. caribaea* y *P. tropicalis* tienen el cuerpo central esferoidal hasta oblato-esferoidales, y las vesículas de menor tamaño.

La exina de la parte proximal en *P. cubensis* y *P. maestrensis* es más gruesa (cerca de 4 μm) que en las otras dos especies (menos de 3 μm). Sin embargo en la parte distal, *P. caribaea* tiene la exina más fina (1 μm) que *P. tropicalis* (1.5 μm) acercándose al grosor que presentan las dos especies de la parte Oriental de la Isla. Por otro lado, la estructura intra-reticulada de las

vesículas en *P. tropicalis*, *P. cubensis* y *P. maestrensis* presentan el mismo grosor en las lúminas y muros. Las lúminas de 1–6 μm de diámetro; muros de 0.5–1 μm de ancho. *P. caribaea* tiene lúminas de 1–4 μm de diámetro y muros de 0.5 μm de ancho.

Se encuentran además otros caracteres que diferencian a *P. cubensis* y *P. maestrensis*. Los granos de polen de *P. maestrensis* son de mayor tamaño que los de *P. cubensis*, así como también las vesículas son más grandes, alcanzando casi el tamaño del cuerpo.

En *P. caribaea* y *P. tropicalis* los granos de polen son más o menos del mismo tamaño y en ambas especies las vesículas son más pequeñas en comparación con las de *P. cubensis* y *P. maestrensis*.

RECONOCIMIENTO

Damos las gracias a los compañeros del Dpto. de Sistemática y Botánica Estructural por las sugerencias realizadas en el manuscrito y a Esperanza SALAS por toda la preparación técnica de este trabajo.

REFERENCIAS

- Alain, H. (1969): *Suplemento de la Flora de Cuba*. Ed. Sucre. Caracas, 150 pp.
 Erdtman, G. (1943): *An Introduction to Pollen Analysis*. New York.
 Erdtman, G. (1965): *Pollen and Spore Morphology, Plant Taxonomy*. Stockholm.
 Erdtman, G. (1966): *Pollen Morphology and Plant Taxonomy of Angiosperms*. Hafner, New York.
 Faegri, K., Iversen, J. (1964): *Textbook of Pollen Analysis*, 2nd ed. Hafner, New York.
 Leon, H. (1964): *Flora de Cuba*. Vol. 1, 441 pp. Cultural, La Habana.
 Read, W. R. (1967): *Taxonomy of the Cycads of the West Indies and Florida*. Fifth conference on cycad toxicity, Miami, Florida.

Lámina 1

1. *Zamia kickxii* Miq., SEM-3200 \times
- 2–4. *Z. kickxii* Miq., 1000 \times
- 5–7. *Z. angustifolia* Jacq., 1000 \times
- 8–9. *Z. latifoliolata* Preneloup, 1000 \times
10. *Z. latifoliolata* Preneloup, lado distal, SEM-3200 \times
11. *Z. latifoliolata* Preneloup, lado proximal, SEM-3200 \times

Lámina 2

- 1–3. *Zamia pygmaea* Sims., 1000 \times
4. *Z. pygmaea* Sims., lado proximal, SEM-3200 \times
- 5–8. *Microcycas calocoma* (Miq.) A. DC., 1000 \times
9. *M. calocoma* (Miq.) A. DC., lado distal, SEM-3200 \times
10. *M. calocoma* (Miq.) A. DC., lado proximal. SEM-3200 \times

Lámina 3

- 1–10. *Podocarpus angustifolius* Griseb.,
- 1–6. y 9–10. Diferentes granos de polen, 1000 \times
- 7–8. Fragmentos del cuerpo, 2000 \times

Lámina 4

- 1-5. *Podocarpus aristulatus* Parl., 1000 ×
6. *P. ekmanii* Urban, 1000 ×
7. *P. ekmanii* Urban, fragmento del cuerpo y una vesícula, 2000 ×
8-10. *P. ekmanii* Urban, la escultura del cuerpo, 2000 ×

Lámina 5

- 1-8. *Podocarpus ekmanii* Urban
1-2. y 4-5. Granos de polen en diferentes posiciones, 1000 ×
3. Fragmento del margen del cuerpo, 2000 ×
6-7. La escultura del cuerpo, 2000 ×
8. Fragmento de la vesícula y cuerpo donde se unen, 2000 ×

Lámina 6

- 1-4. *Pinus tropicalis* Morelet
1-3. Diferentes granos de polen, 1000 ×
4. Fragmento del margen del cuerpo, 2000 ×
5-6. *Pinus cubensis* Griseb., 1000 ×

Lámina 7

- 1-5. *Pinus caribaea* Morelet
1. y 4-5. Diferentes granos de polen, 1000 ×
2-3. Fragmentos del cuerpo, 2000 ×
6-8. *Juniperus lucayana* Britt., 1000 ×

Lámina 8

- 1-4. *Pinus maestrensis* Bisse
1-3. Granos de polen en diferentes vistas, 1000 ×
4. Fragmento de una vesícula, 2000 ×

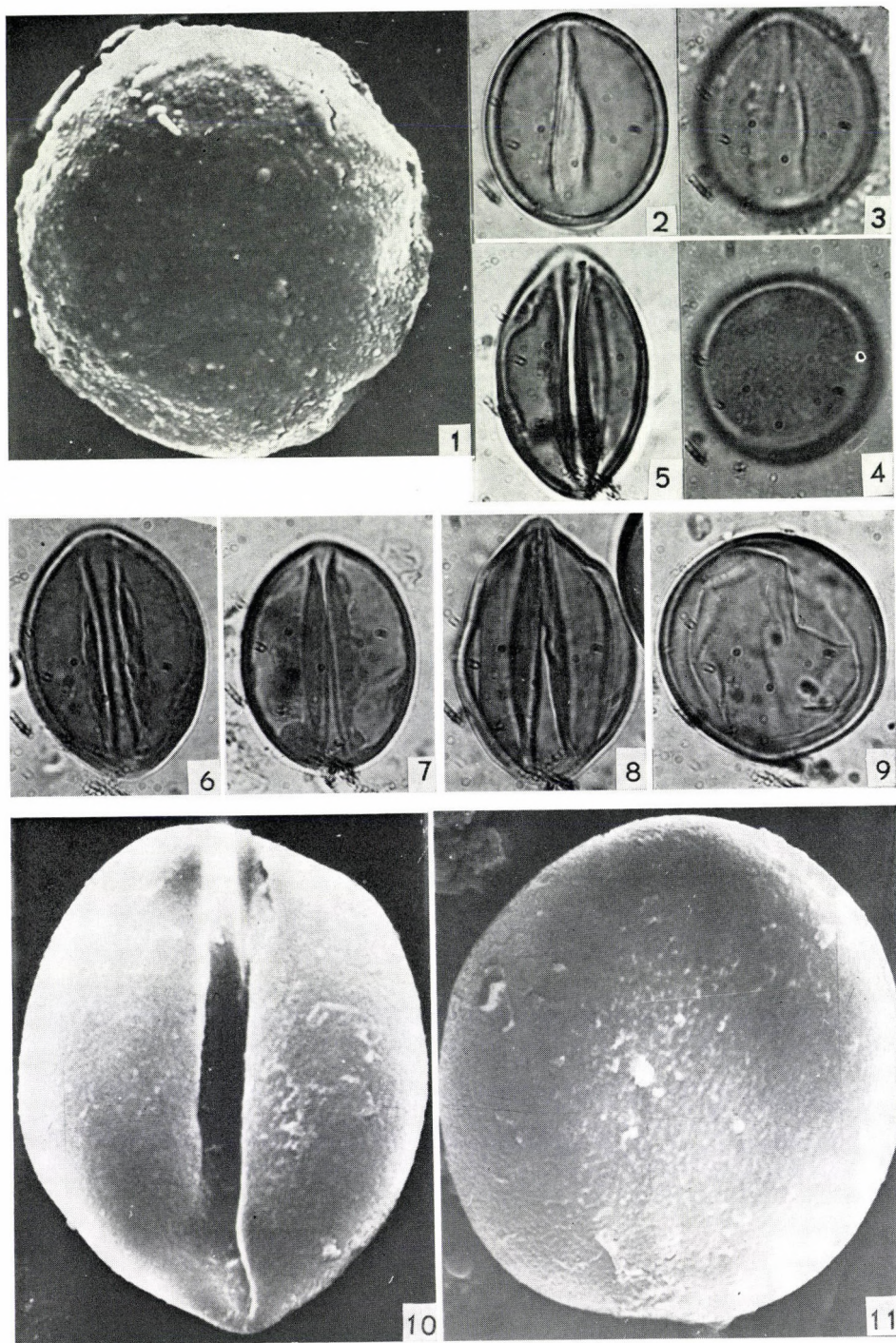


Lámina 1

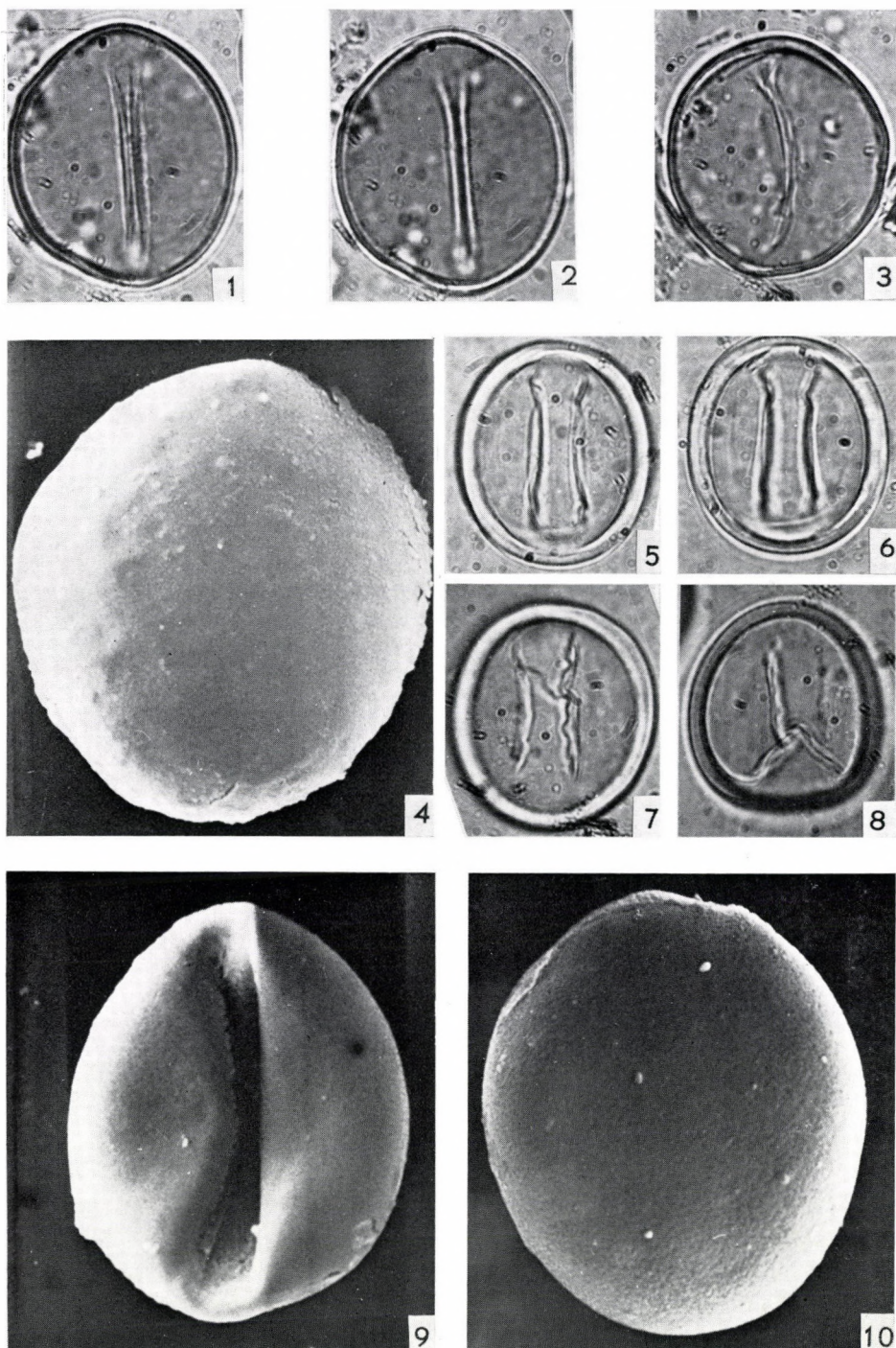


Lámina 2

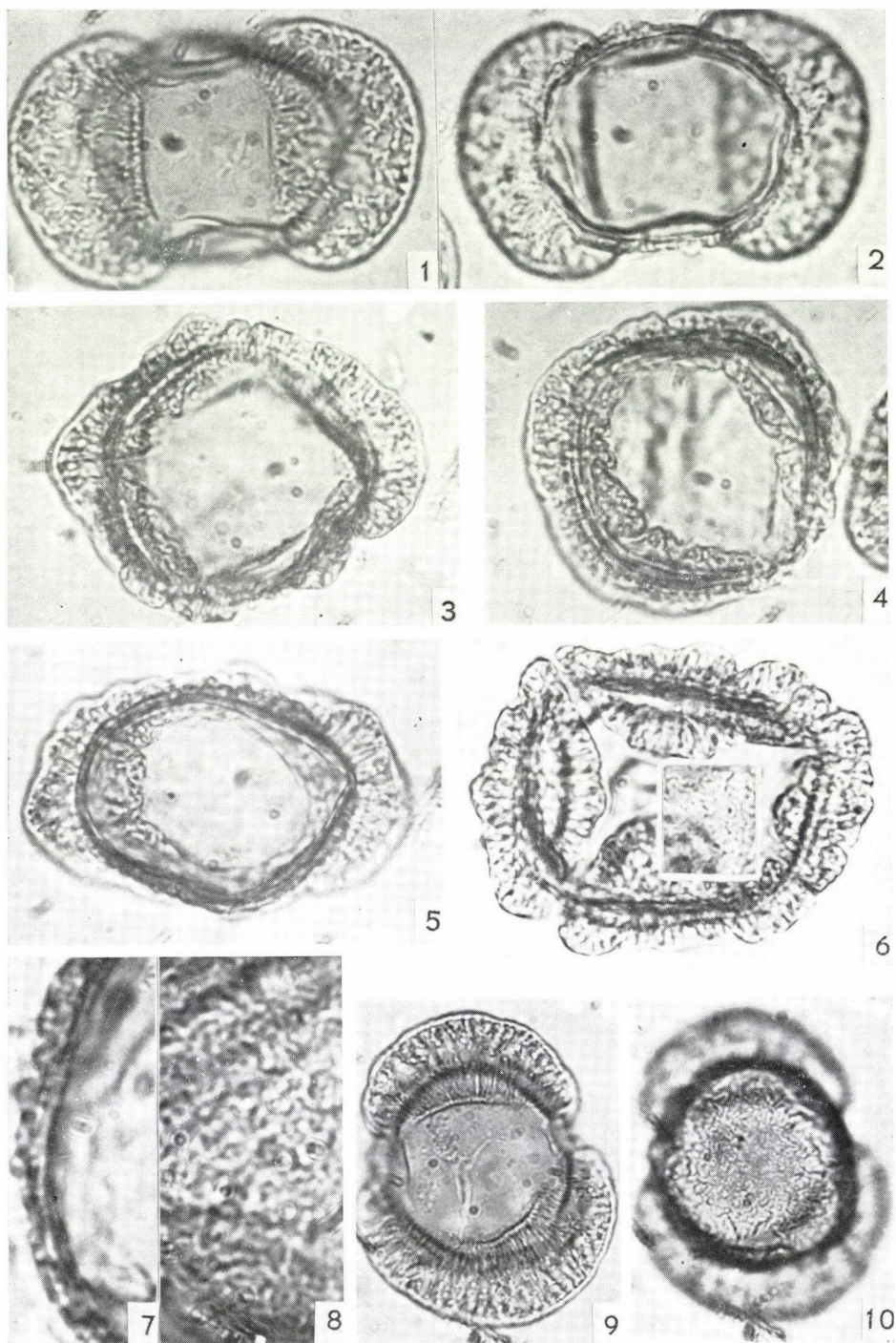


Lámina 3

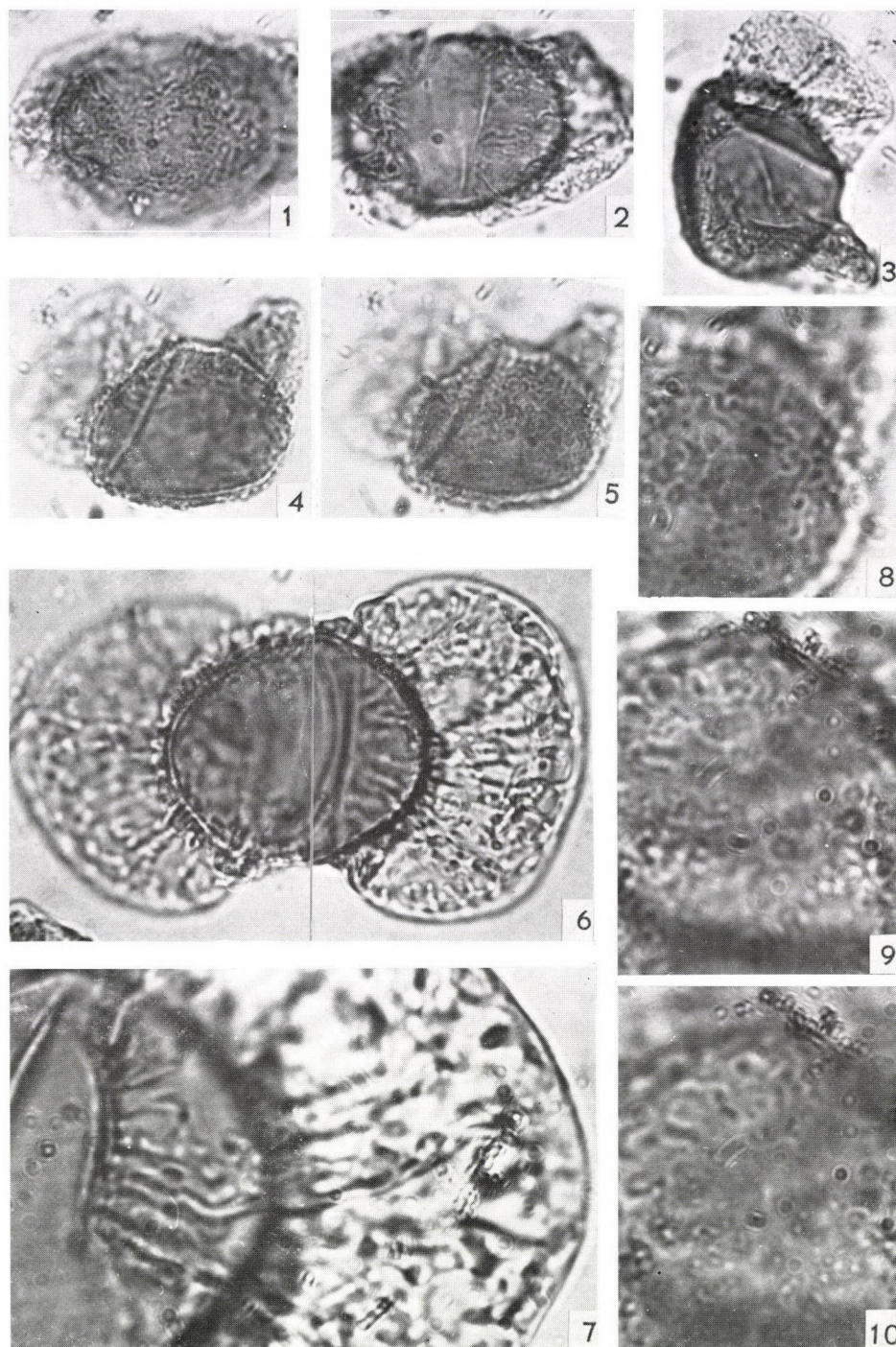


Lámina 4

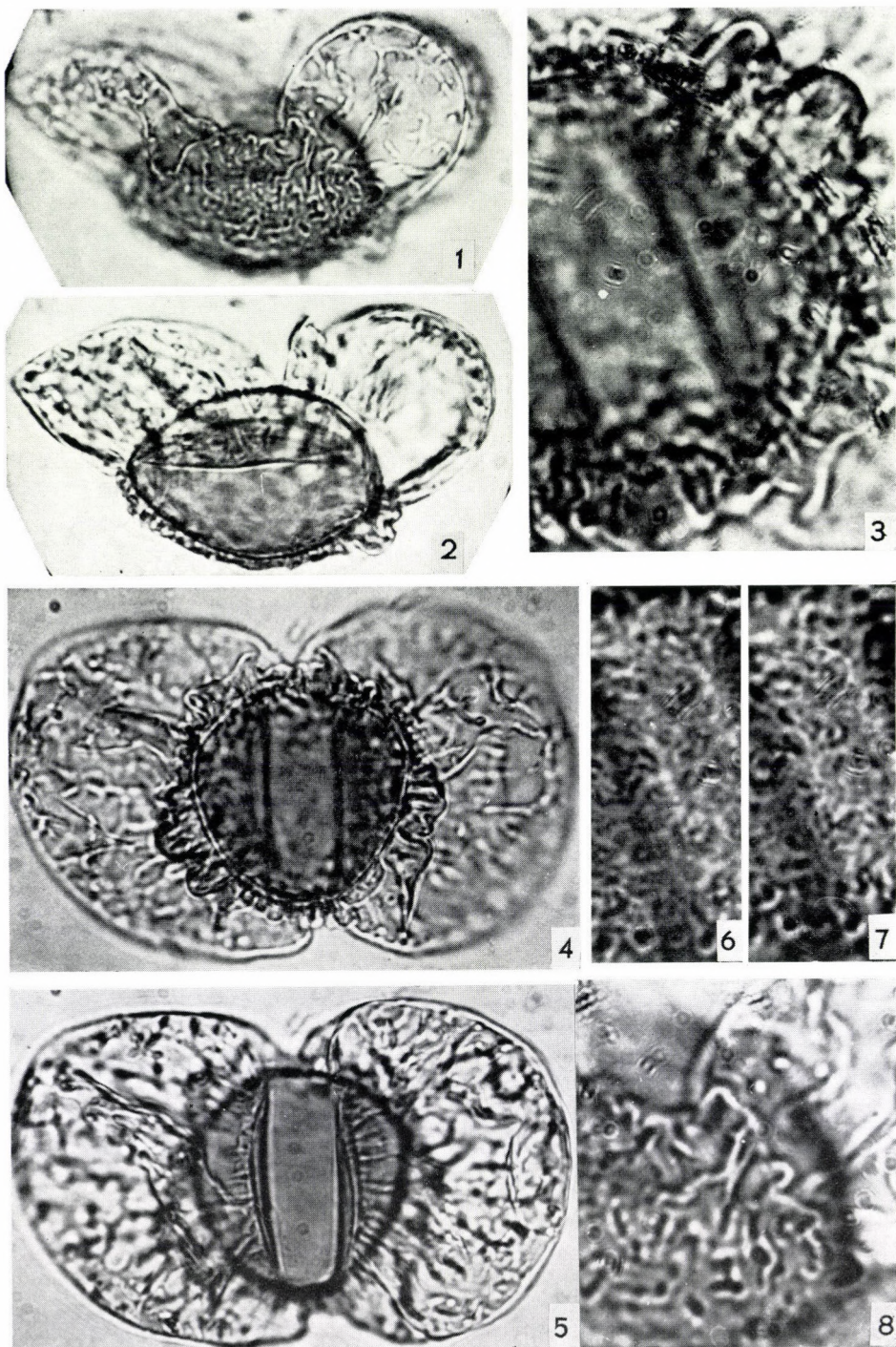


Lámina 5

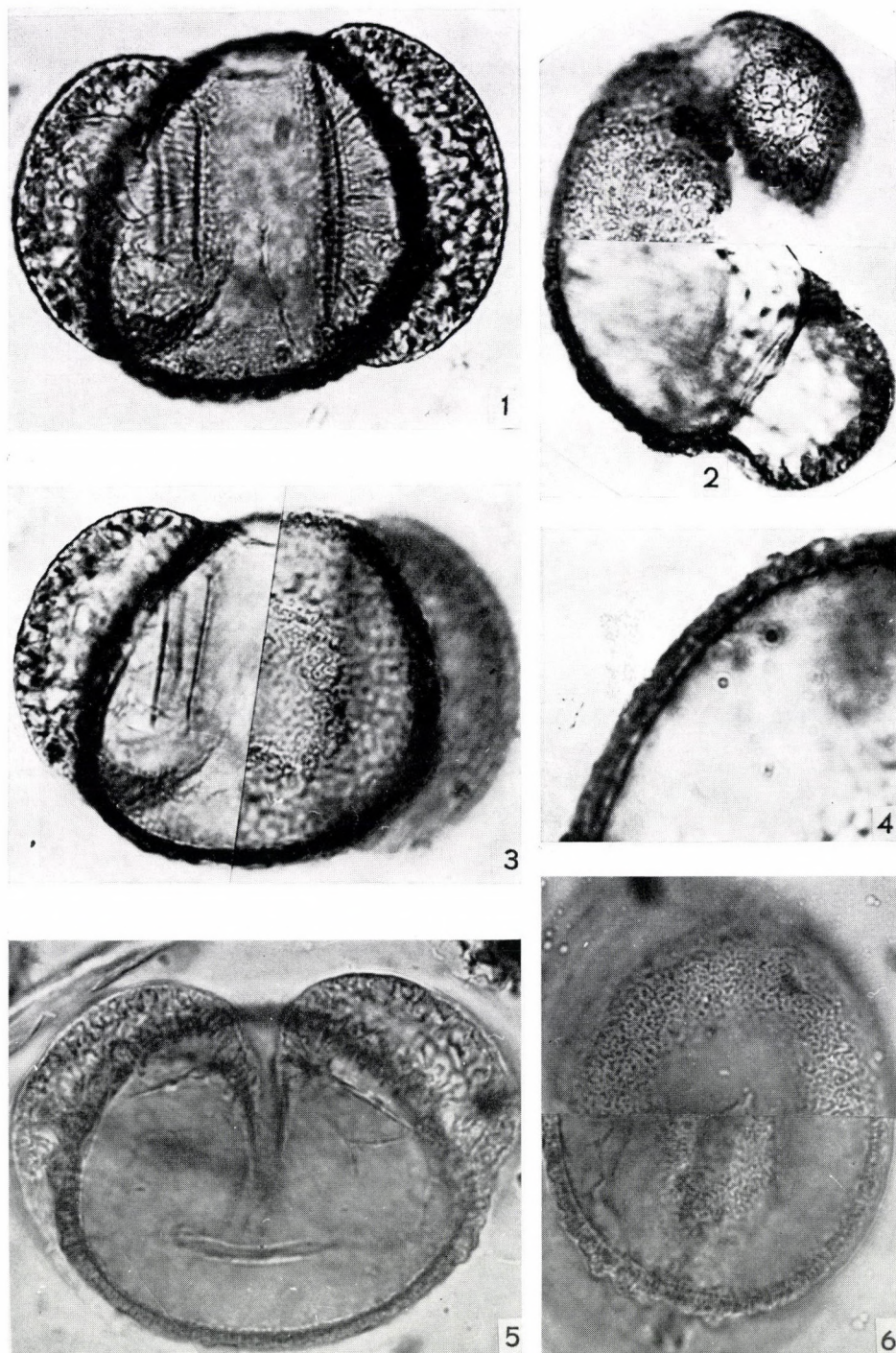


Lámina 6

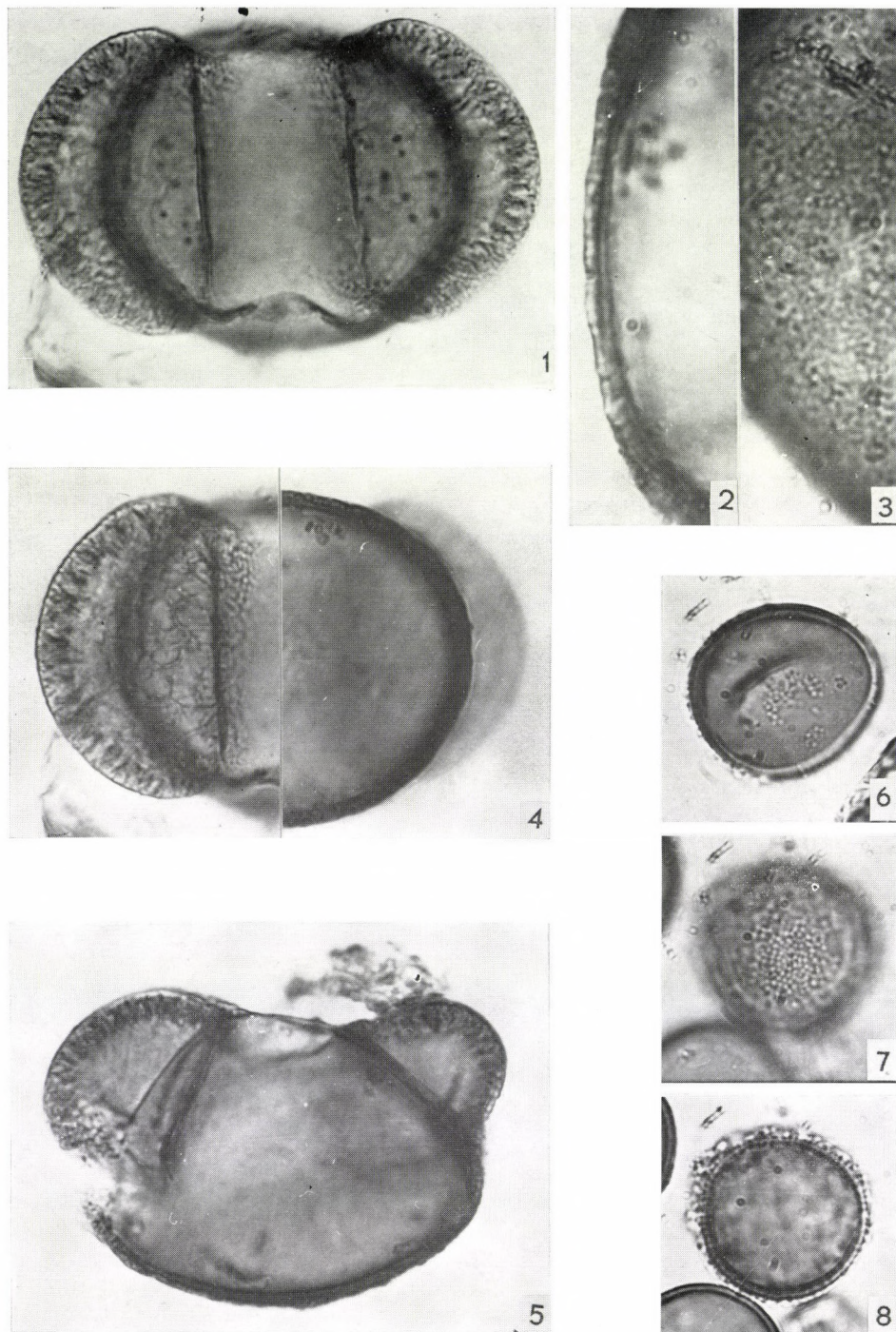


Lámina 7

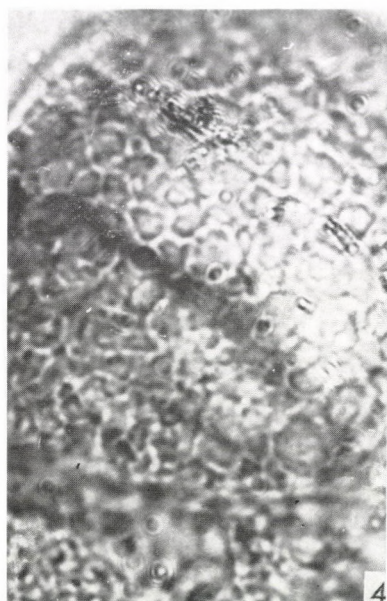
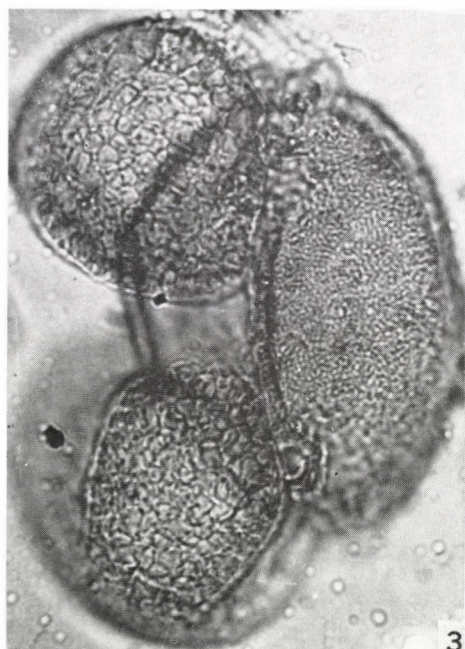
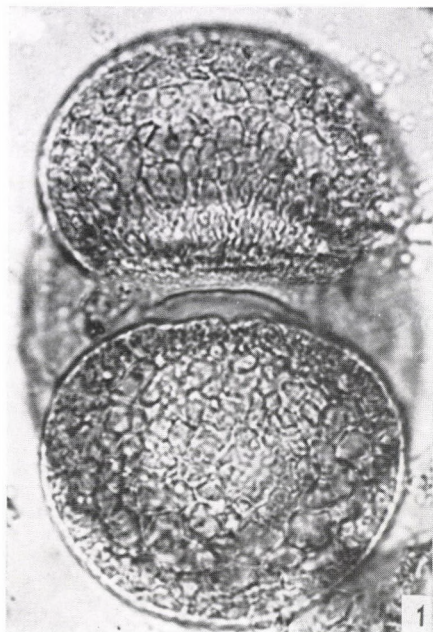


Lámina 8

A COMPENDIUM OF THE MORPHOLOGY OF *PHYTOPHTHORA CINNAMOMI* RANDS FROM AUSTRALIA

L. GERRETTSON-CORNELL

FORESTRY COMMISSION OF NEW SOUTH WALES

(Received: 15 January 1983)

Twenty isolates of *Phytophthora cinnamomi* from various States of Australia have been described. All data has been used to define what could be regarded as a morphological prototype of *P. cinnamomi* from this country.

Phytophthora cinnamomi Rands is a pathogen of widespread occurrence and has given rise to serious concern in Australia since its association with die back in native forests of jarrah (*Eucalyptus marginata* Sm.) was reported (PODGER et al. 1965). Whatever its origin, *P. cinnamomi* has been associated with a great deal of damage to forests in Australia including patch die back of rainforest in Queensland; die back of native eucalypt forest in Victoria; and death of Jarrah forest in Western Australia (GERRETTSON-CORNELL and DOWDEN 1979). In New South Wales *P. cinnamomi* occurs from the Queensland to the Victorian borders and as far inland as Parkes and Narromine. In spite of its wide distribution the fungus has not been found associated with any major areas of death or die back of forest trees. Nevertheless continued vigilance is required because on some occasions it was found associated with small areas of die back and ill-health of trees in this State. Research into the "Phytophthora problem" in New South Wales has generally shown a combination of causes. Wherever disease of plants in this State was investigated which might have been related to the presence of this fungus, other conditions were also present which might have represented either the primary or the secondary cause of disorder (GERRETTSON-CORNELL 1979a). Having briefly reviewed the situation of *P. cinnamomi* in Australia, the most important morphological features of this species from this country are hereunder described and discussed. The present study which has been based on twenty isolates recovered from all States of Australia except the Northern Territories, is meant to be a unified, comprehensive description of the fungus.

Materials and methods

(a) *Origin of cultures*

The origin of the cultures of *Phytophthora cinnamomi* used in this study are listed in Table 1. Their identity was assessed or confirmed by the author prior to the beginning of this work by using the keys of WATERHOUSE (1954, 1963) and FREZZI (1950).

(b) *Mycelial growth and sporangial formation*

The present study was carried out on corn meal agar and V-8 agar as hereunder indicated — Corn meal agar (CMA) (Difco, 17 g/l). This medium is commonly used in *Phytophthora* studies and was also used by WATERHOUSE (1963) for her key. On corn meal agar many *Phytophthoras* show a "coralloid" type of growth with very scarce aerial mycelium which enables a clear vision of the colony by direct microscopical examination of the cultures in the plates.

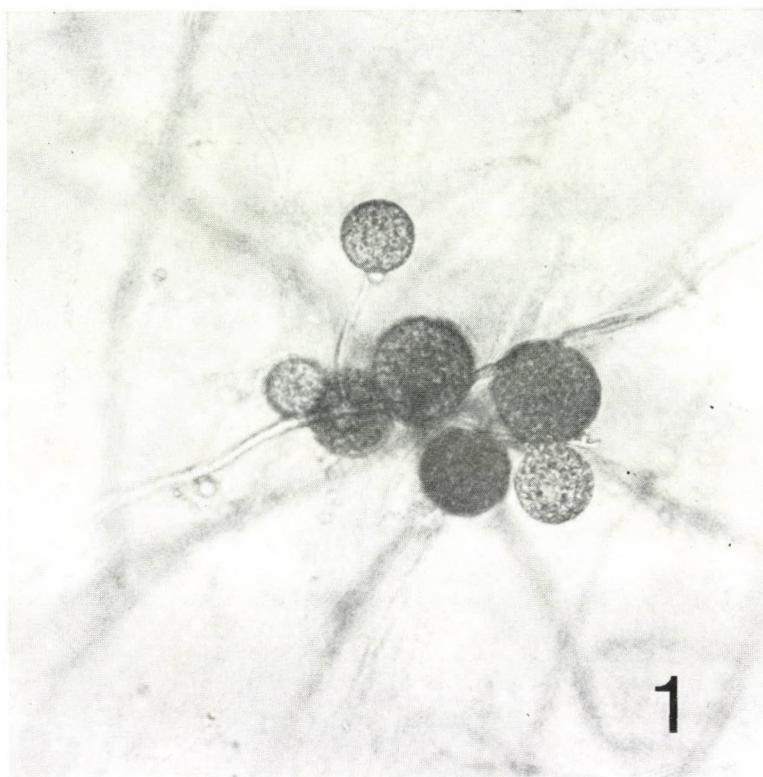


Fig. 1. Chlamydospores in clusters. $\times 240$

— 2% V-8 juice agar, uncentrifuged, pH 4.5–4.6. This medium, like CMA, enables a direct examination of cultures under the microscope and is also an optimum substratum for the production of chlamydospores, sporangia and oogonia by various *Phytophthora* species. V-8 agar was found to be the best to induce sporangia formation by the cotyledon method (GERRETSON-CORNELL, 1975, 1980). The only negative aspect in the use of this medium is the fact that its composition may vary, especially from one country to another. In Australia results so far obtained with this medium indicate that its composition does not vary much.

For each isolate on CMA and V-8 agar three plates were established, inoculated centrally with a disc of agar mycelium set upside-down and incubated in darkness at $25 \pm 1^\circ\text{C}$. They were examined every 2 days for 2 weeks when data were collected. After this preliminary examination cultures were continuously renewed for further study over a period of 2–3 months and checked from all possible angles.

Finally, formation of sporangia was obtained by the cotyledon method (GERRETSON-CORNELL 1975, 1980).

(c) Growth rate in the presence of malachite green

Nine isolates randomly selected from those of the present study were tested for growth on V-8 agar with different concentrations of malachite green. The experiment was carried out in triplicate and results were compared with those of the controls (V-8 agar without malachite). The test was carried out at $25 \pm 1^\circ\text{C}$, in darkness over a period of four days.

(d) *Sexual organs formation*

To induce formation of oogonia, the few A1 compatibility types of this investigation were paired with the A2 strains, on 2% V-8 agar. Cultures were kept at $25 \pm 1^\circ\text{C}$, in darkness for two weeks and examined every two days. Homothallism was checked in 1 month old single cultures, inoculated centrally in the plate.

(e) *Terminology*

BLACKWELL's (1949) terminology has been used with some minor additions as follows.

- Swollen hypha. It is an hypha or part of it, usually a long segment that is markedly enlarged. It may either be uniformly or irregularly enlarged.
- Coralloid hypha. Coralloid hyphae are generally branches of first and second order and are irregularly shaped. A mycelium is coralloid if it is formed prevalently of coralloid hyphae, either with or without swollen hyphae. Coralloid hyphae may be single in which case they may be either alternate or opposite or be arranged in verticils on the bearing hypha. Coralloid hyphae may also bear one and even more swellings and/or chlamydospores.
- Swellings and chlamydospores. A swelling is a comparatively small portion of an hypha which is markedly enlarged to form a globose, subglobose, or irregularly shaped body. It can be either sessile, terminal or intercalary, single or in clusters. *P. cinnamomi*, particularly on V-8 agar, produces botryose, thin-walled, greyish to yellow-brownish swellings and/or chlamydospores, either globose, subglobose or irregularly shaped. It is often difficult to distinguish swellings from chlamydospores because the septum which is a major characteristic of the chlamydospore can rarely be seen.



Fig. 2. Swellings and chlamydospores in the process of subdivision. $\times 650$



Fig. 3. Chain of 2 chlamydospores. $\times 640$

— "Oospore proper." It is herein defined as the central rounded body of the whole structure which has no further visible dividing layers when viewed under transmitted light bright field or phase microscopy. The innermost wall which bounds the oospore and which shows no further layers under the same conditions as above is referred to as the "inner oospore wall". In the present work the size referred to is that of the oospore proper.

Results and discussion

Mycelium

All isolates of *P. cinnamomi* on CMA produced a colourless to white mycelium submerged into the agar with nil or very poor aerial growth. Colonies on this medium were entirely or almost entirely coralloid. Hyphae were coenocytic but became septate with age. The diameter of the regular hyphae was of ca 6–9 μm .

Swellings were formed and were terminal or sessile, sparse or in clusters. Chlamydospores were only formed in some strains and occurred singly or in groups of up to 10–15. They were particularly abundant in certain strains such as DAR 37637, DAR 37651, DAR 37656 and 6253. Neither sporangia nor organs of fusion were formed on CMA.

On V-8 agar the aerial mycelium was slightly more abundant than on CMA but still very poor. It was white, lanose and composed mostly of hyphae of uniform diameter, coenocytic and later septate, of ca. 5–8 μm in diameter. Coralloid hyphae were present but not as much as on CMA. The colony was generally radiate and of even texture. All isolates of *P. cinnamomi* formed abundant botryose, yellowish-brownish or greyish-yellowish thin walled ($< 1\text{--}2\ \mu\text{m}$) swellings and chlamydospores on this medium (Fig. 1). On one occasion however a net-like type of configuration was observed inside one of these large groups. It was clearly observed to have originated by proliferation from each single swelling or chlamydospore rather than being an enlargement at more or less regular intervals of the same hypha (GERRETSON-CORNELL 1980). Chlamydospores were mostly spherical, and born at the apex of a stalk which varied in length from a few to ca. 130 μm .

A few intercalary swellings were observed in nine isolates. One isolate, DAR 37635, did not always produce chlamydospores. One isolate (No. 8) also showed an interesting phenomenon. The swelling which seemed destined to become a chlamydospore shrunk in one or two points thus forming what appeared to be the initial of a separating septum (Fig. 2). In this way, small chains of two chlamydospores were formed (Figs 3, 4). This phenomenon was also observed in a few other strains, especially No. 93 but to far less an extent than in No. 8.

In Table 2 the size of 50 chlamydospores of each strain on V-8 agar is reported. Neither sporangia nor sexual organs were formed on V-8 agar.

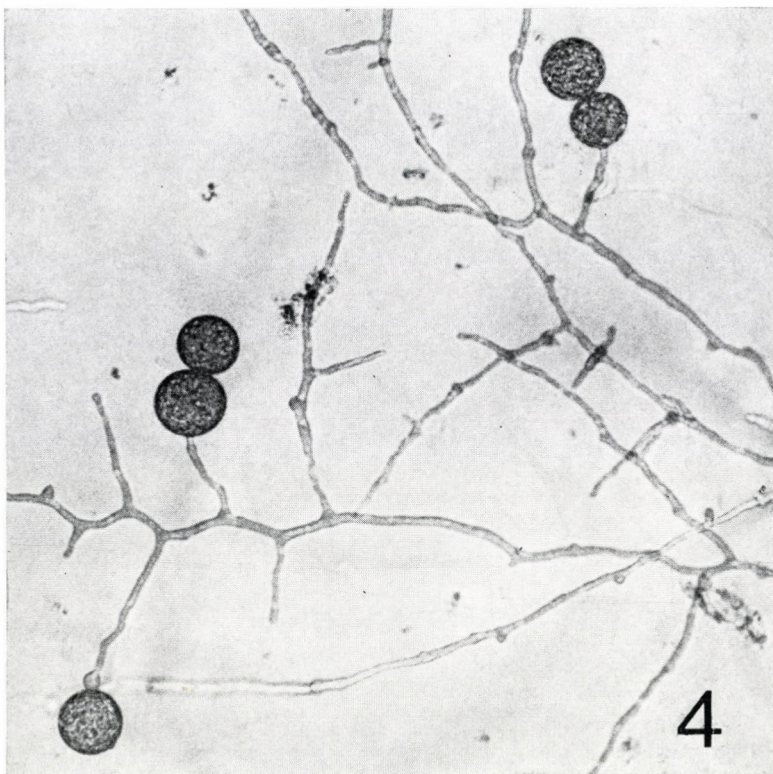


Fig. 4. Chains of 2 chlamydospores. $\times 260$

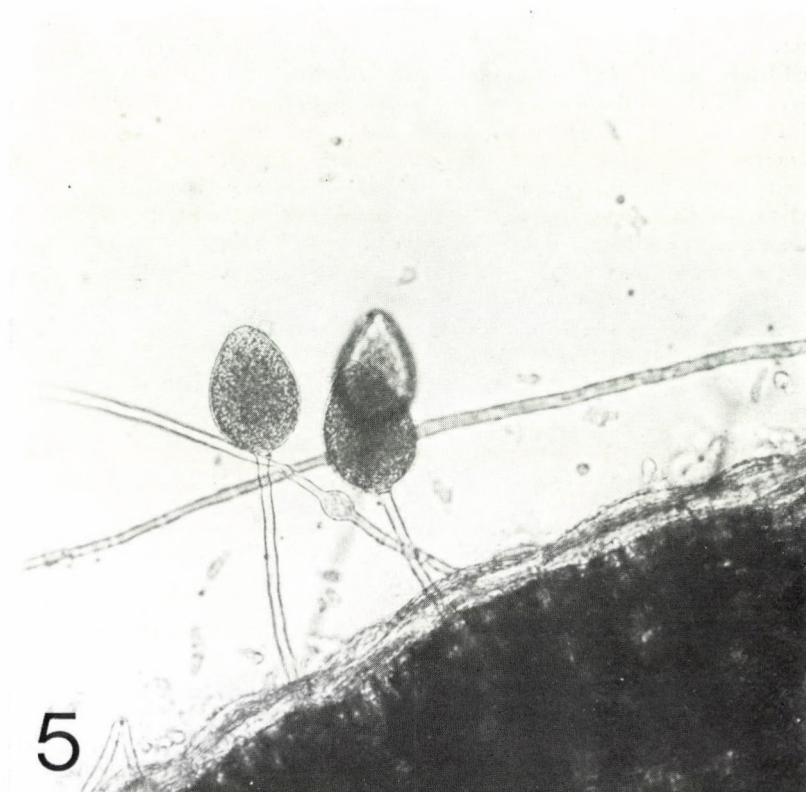


Fig. 5. Sporangia at the edge of cotyledons. $\times 280$

Sporangia

As regards the formation of sporangia by the cotyledon method, they were produced abundantly by all strains, both at the edge of cotyledons (Figs 5, 6) and the surrounding agar. Sporangia were formed at the apex of a sporangiophore that could vary from a few to $400\ \mu\text{m}$ in length. The diameter of the sporophore which was more frequently unbranched, was $4\text{--}7\ \mu\text{m}$. Sympodial branching of the sporophore was also observed (Table 3) except in isolates Nos 103, 3477, SC50. It occurred immediately below the sporangium. Both the extended and nested (Fig. 7) proliferation of the sporangiophore were observed. However the latter type was never shown by isolate 3477.

Sporangia were non papillate ($\bar{x} < 3\ \mu\text{m}$) and had a wide pore ($\bar{x} > 7\ \mu\text{m}$). They were non-pedicillate (pedicel length = ca. $2.5\ \mu\text{m}$) and generally non-deciduous. However a few isolates (DAR 37637, DAR 37651, DAR 37656), upon vigorous handshaking for 1–2 minutes showed the detachment of up to 50% of the sporangia from their stalk at points 3 to $250\ \mu\text{m}$ from the base of the sporangium. That is, the length of the stalk attached to the sporangium varied considerably. Because a *Phytophthora* species is "considered caducous only if a certain percentage of sporangia are detached at maturity and if detached sporangia carry a pedicel of uniform length" (AL-HEDAITHY and TSAO 1979), in this sense the sporangia of the isolates

mentioned above are to be regarded as non-caducous. Only a few sporangia were abstricted from the sporangiophore in still cultures.

With regard to the shape of the sporangia, they were more frequently broadly ovoid, ellipsoid, limoniform and even obpyriform. They were symmetrical or slightly asymmetrical with the apex more or less protruding, the membrane at times forming a structure reminiscent of a cap above the apex (GERRETSON-CORNELL and LIND 1981). Sporangial polymorphism was more accentuated in some isolates than others and even more in sporangia of second and third formation.

Finally, in Table 4 the dimensions of the sporangia of each isolate of *P. cinnamomi* are collated. Both the direct and indirect type of sporangial germination were observed. Under the conditions of experiment the indirect type (i.e. by zoospores) occurred more frequently. The direct type (i.e. by one or more hyphae) was observed both in vacuolated and non-vacuolated sporangia. As already pointed out for *P. cryptogea* (GERRETSON-CORNELL 1979b), sporangia of *P. cinnamomi* with one or more vacuoles germinated by germ tube; they were never seen to form zoospores. This fact could have some important repercussions in the field, on the pathogenicity of the fungus. In fact, depending on which type of sporangial germination prevails, the degree of infection by the fungus could be different. When zoospores were formed within the sporangium, they were expelled singly, in rapid succession. Alternatively, the sporangium expelled the whole protoplasm and this broke into single units immediately after release. Also, but less frequently, the protoplasm was held at the mouth of the sporangium

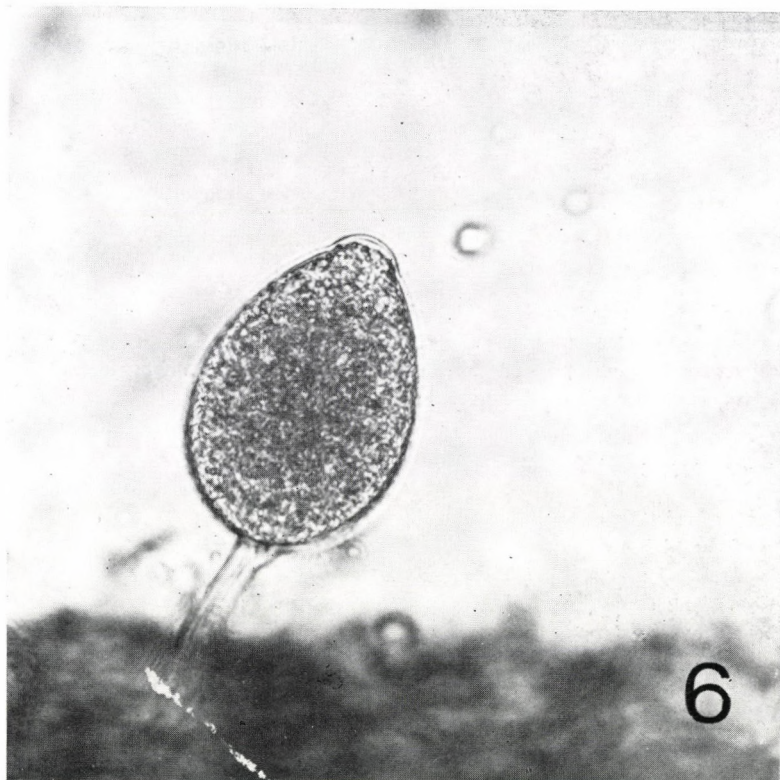


Fig. 6. Sporangium at the edge of cotyledon. $\times 620$

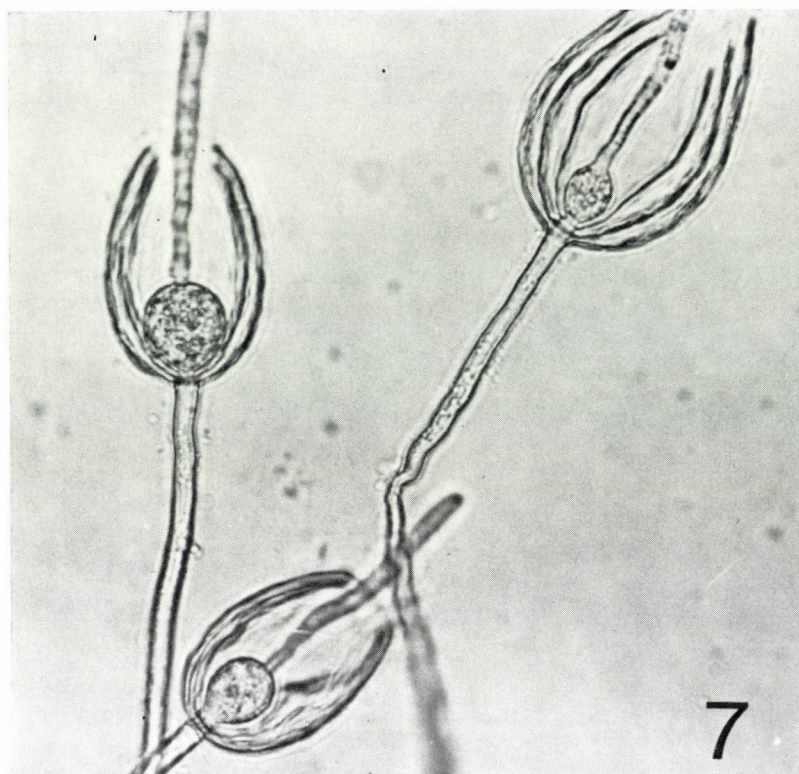


Fig. 7. "Nested" type of sporangiophore. $\times 560$

for a few seconds; from this, small portions of protoplasm separated in regular succession and gave rise to one or even two zoospores.

Zoospores were motile, 10–19 μm long; encysted, 8–15 μm . They germinated by one and even two germ tubes within 2–3 h after encysting.

Malachite green test

Results of this test are collated in Table 5.

Two of the nine strains tested showed some ability to utilize malachite green at concentrations of up to 1 : 2 000 000 (Table 5). All other strains were practically inhibited by that concentration. They showed nonetheless some growth at 1 : 4 000 000 level. All isolates of *Phytophthora* showed moderate growth but always significantly ($P 0.01$) less than the controls, at lower concentrations of malachite green in the medium.

Oogonia formation

None of the strains of the present study was found to be homothallic, under the conditions of experiment. The organs of fusion were always formed heterothallically. The oogonium

was almost perfectly spherical. The average size was $43\ \mu\text{m}$ whereas its dimensions range was 33 to $52\ \mu\text{m}$. The oospore size varied from 24 to $45\ \mu\text{m}$, the average being ca. $37\ \mu\text{m}$. It was plerotic and occasionally aplerotic. Its colour was greyish with a yellowish-brownish shade at the periphery. The antheridium, always amphigynous, was either spherical or oblong (Figs 8, 9). The shape of the base of the oogonium within the antheridium was similar to a broad funnel, especially when the antheridium was extended. The dimensional range of the antheridium was $12\text{--}27 \times 14\text{--}21\ \mu\text{m}$, average $19 \times 17\ \mu\text{m}$. The antheridium was generally unicellular, occasionally bicellular.

Conclusions

On the basis of the foregoing description the most important morphological features of *P. cinnamomi* from Australia are summed up as follows:

- Culture appearance on CMA typically “coralloid” or radiate, often with an indefinite margin. On V-8 agar, mostly radiate with scarce, white aerial mycelium.

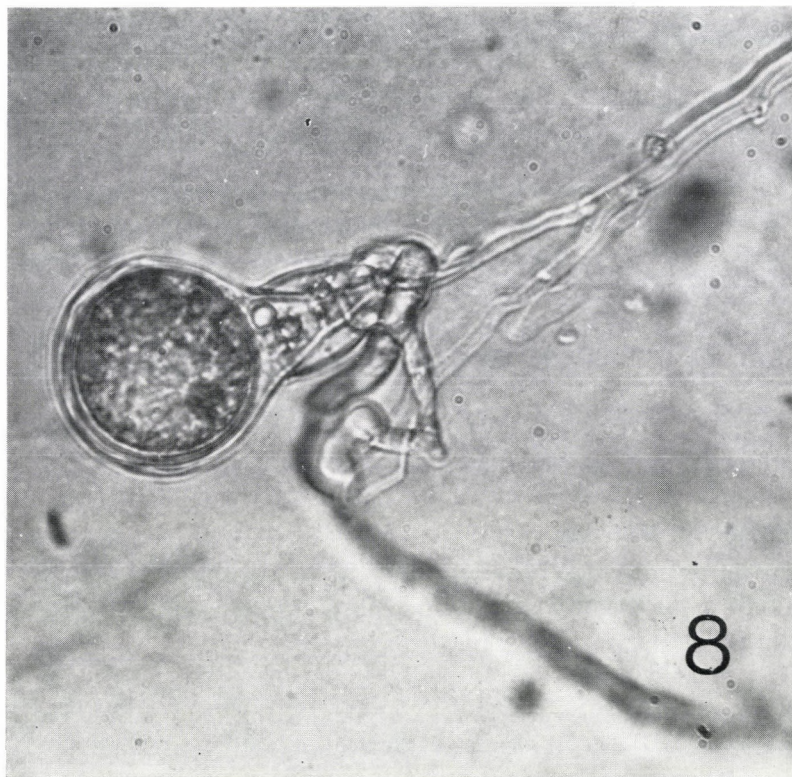


Fig. 8. Oogonium with an extended type of antheridium. $\times 630$

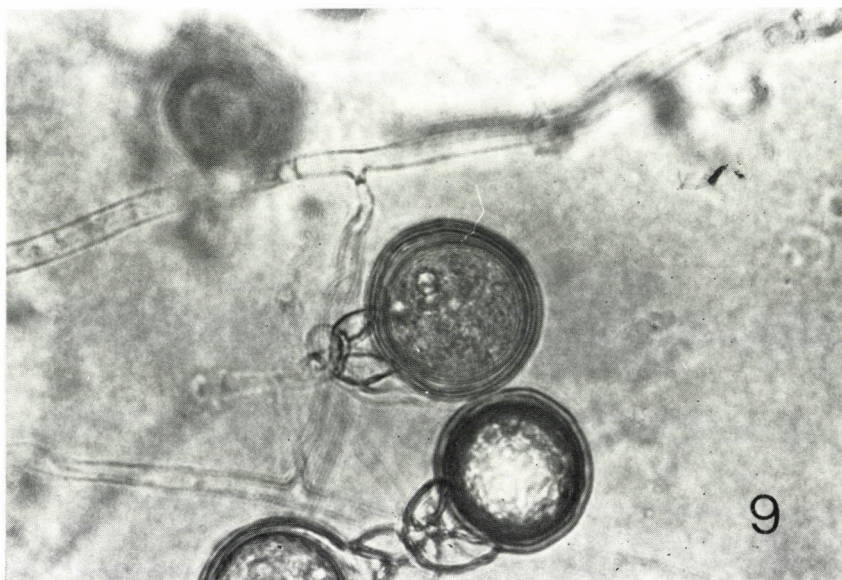


Fig. 9. Oogonia with a spherical type of antheridium. $\times 600$

- On CMA, hyphae coenocytic, septate when old, mostly coralloid (sparse or in clusters). More regular hyphae on V-8 agar. Dimensional range of hyphae on CMA, 6–9 μm ; on V-8 agar, 5–8 μm .
- Hyphal swellings present on CMA as well as V-8 agar, spherical or irregular, thin walled, sparse or in clusters, terminal or sessile, rarely intercalary.
- Chlamydospores readily formed on V-8 agar, less or none at all on CMA. The former appears to be the best medium so far tested for the production of these organs. Terminal. Dimensional range, 10–70 μm , average 36 μm . Mostly spherical, but also subspherical or irregular, thin walled, greyish to yellowish brown, sparse or in clusters.
- Sporangiophores mostly simple or sympodially branched, the new branch originating immediately below the sporangium. Proliferation through the empty sporangium also frequently observed. Up to 400 μm ; 4–7 μm in diameter.
- Sporangia never formed directly on solid media. More frequently limoni-form, ellipsoid, broadly ovoid, obpyriform. Polymorphism accentuated in certain isolates more than others. Non-papillate ($\bar{x} < 3 \mu\text{m}$), non-pedicillate (pedicel length up to 2–3 μm), not-deciduous in the majority of cases. Dimensional range 22–92 \times 17–62 μm , average 54 \times 39 μm . Ratio length/breadth range 1.1–2.3, average 1.4. Exit pore diameter range 4–18 μm , average 10 μm .
- Zoospores motile, 10–19 μm long, encysted 8–15 μm diameter.

- Malachite green. Strains grew at 1 : 4 000 000, a few at 1 : 2 000 000. Growth at 1 : 8 000 000.
- Heterothallic. Oogonia spherical, greyish to yellow brownish, wall smooth. Dimensions range 33–52 μm , average 43 μm . Oospore more frequently plerotic, aplerotic in some cases, yellowish brown, dimensions range 24–45 μm , average 37 μm .
- Antheridium amphigynous, spherical to oblong, more frequently unicellular; dimensions range 12–27 \times 14–21 μm , average 19 \times 17 μm .

REFERENCES

- Al-Hedaithy, S. S. A., Tsao, D. H. (1979): Sporangium pedicel length in *Phytophthora* species and consideration of its uniformity in determining sporangium caducity. *Trans. Br. Mycol. Soc.* **72**: 1–13.
- Blackwell, E. (1949): Terminology in *Phytophthora*. *Mycological Papers* No. 30 Commonwealth Mycological Institute, Kew, Surrey, England.
- Frezzi, M. (1950): *Las especies de Phytophthora en la Argentina*. Ministerio de Agricultura y Ganadería, Buenos Aires.
- Gerrettson-Cornell, L. (1975): Notes on the formation of sporangia in *Phytophthora drechsleri* Tucker. *APPS Newsletter* **4**: 32–33.
- Gerrettson-Cornell, L. (1979a): Some observations on *Phytophthora* spp. in soil with particular reference to *P. cinnamomi* Randb in New South Wales. *Phyton* **37**: 69–72.
- Gerrettson-Cornell, L. (1979b): Notes on the morphology of five isolates of *Phytophthora cryptogea* Pethyb. and Laff. from Australia. *Phyton* **37**: 105–118.
- Gerrettson-Cornell, L., Dowden, H. (1979): Forestry and *Phytophthora* in N.S.W. *Forest & Timber* **14**: 7–8.
- Gerrettson-Cornell, L. (1980): Notes on the morphology of some isolates of *Phytophthora* from Australia. *Cryptogamie, Mycologie* **1**: 139–154.
- Gerrettson-Cornell, L., Lind, P. (1981): Observations on the sporangial shape in *Phytophthora*. *Phyton* **40**: 31–35.
- Podger, F. D., Doepel, R. F., Zentmyer, G. A. (1965): Association of *Phytophthora cinnamomi* with a disease of *Eucalyptus marginata* forest in Western Australia. *Plant Dis. Repr.* **49**: 943–947.
- Waterhouse, G. M. (1954): Key to the species of *Phytophthora* recorded in the British Isles. *Mycological Papers*, No. 57. *Commonw. Mycol. Inst. Kew, Surrey*.
- Waterhouse, G. M. (1963): Key to the species of *Phytophthora* de Bary. *Mycological Papers* No. 92. *Commonwealth Mycological Institute, Kew, Surrey, England*.

Table 1*List of isolates of Phytophthora cinnamomi used in this study*

Strain No.	Species	Mating type	Area of origin	Donor	Host association
8	<i>P. cinnamomi</i>	A1	Ourimbah, N.S.W.	Author	<i>E. saligna</i>
36	<i>P. cinnamomi</i>	A2	Eden, N.S.W.	Author	<i>E. sieberi</i>
93	<i>P. cinnamomi</i>	A2	Sunny Corner, N.S.W.	Author	<i>P. radiata</i>
102	<i>P. cinnamomi</i>	A2	Madden's Plain, N.S.W.	Author	<i>E. gummifera</i>
51	<i>P. cinnamomi</i>	A2	Wyong, N.S.W.	Author	<i>E. paniculata</i>
103	<i>P. cinnamomi</i>	A2	West Pennant Hills, N.S.W.	Author	<i>E. pilularis</i>
DAR 19881	<i>P. cinnamomi</i>	A2	Mt. Kuringgai, N.S.W.	J. WALKER	<i>Pimelea rosea</i>
DAR 25999	<i>P. cinnamomi</i>	A2	Kenthurst, N.S.W.	J. WALKER	<i>Actiridia chinensis</i>
T240	<i>P. cinnamomi</i>	A2	Waterfall Bay, Tas.	F. PODGER	<i>E. obliqua</i> and <i>Pultenea</i> sp.
3477	<i>P. cinnamomi</i>	A2	Kuranda, Qld.	B. BROWN	Rainforest soil
3392	<i>P. cinnamomi</i>	A1	Kuranda, Qld.	B. BROWN	Rainforest soil
SC50	<i>P. cinnamomi</i>	A1	Manjimup W.A.	J. TITZE	Unknown
SC90	<i>P. cinnamomi</i>	A2	Kirrup, W.A.	J. TITZE	<i>E. marginata</i>
DAR 37635	<i>P. cinnamomi</i>	A2	Tasmania	J. WALKER	Unknown
DAR 37636	<i>P. cinnamomi</i>	A2	Brisbane Ranges, Victoria	J. WALKER	Unknown
DAR 37637	<i>P. cinnamomi</i>	A2	Brisbane Ranges, Victoria	J. WALKER	Unknown
DAR 37651	<i>P. cinnamomi</i>	A1	Bribie Island, Queensland	J. WALKER	Acacia sp.
DAR 37656	<i>P. cinnamomi</i>	A1	Murwillumbah, N.S.W.	J. WALKER	Dune vegetation
6210	<i>P. cinnamomi</i>	A2	Bondo (Tumut, N.S.W.) nursery	R. KEIRLE	<i>Pinus radiata</i>
6253	<i>P. cinnamomi</i>	A2	Bondi (Bombala, N.S.W.) nursery	R. KEIRLE	<i>P. radiata</i> seedlings

Table 2

Mycelium characteristics of the isolates of P. cinnamomi on 2% V-8 agar

Strain No.	CH	SH	S		Cl	Cld (μ m)	Sp	Of
			T	I				
8	++	+	++	—	++	27 (17-53)	—	—
36	++	+	++	+	++	31 (18-51)	—	—
93	++	++	++	+	++	33 (10-56)	—	—
102	++	+	++	—	++	37 (22-59)	—	—
51	++	+	++	+	++	35 (18-49)	—	—
103	++	+	++	—	+	31 (15-48)	—	—
DAR 19881	++	+	++	—	++	44 (22-55)	—	—
DAR 25999	++	++	++	+	+	33 (15-48)	—	—
T240	++	+	++	—	++	34 (15-55)	—	—
3477	++	+	++	+	++	41 (16-66)	—	—
3392	++	+	+	+	++	41 (22-59)	—	—
SC50	++	+	++	+	+	34 (15-48)	—	—
SC90	++	—	++	—	+	35 (22-48)	—	—
DAR 37635	+, ++	+	++	—	— to +	27 (22-48)	—	—
DAR 37636	++	+	+, ++	—	++	41 (18-59)	—	—
DAR 37637	+, ++	+	+, ++	—	++	38 (18-55)	—	—
DAR 37651	+	+	+	—	++	38 (18-59)	—	—
DAR 37656	++	+	+	—	++	47 (26-70)	—	—
6210	+, ++	+	++	+	++	36 (18-55)	—	—
6253	++	+	++	—, +	++	37 (18-62)	—	—

— = none observed
 SH = swollen hyphae
 I = intercalary
 Cl = chlamydospores

+ = scarce
 S = swellings
 T = terminal and/or sessile
 Cld = chlamydospores
 dimensions

++ = abundant
 CH = coraloid hyphae
 Sp = sporangia
 Of = organs of fusion

Table 3

P. cinnamomi: Morphological characteristics on 2% V-8 agar, under water and sporangia production by the cotyledon method

Strain No.	Sporangia formation	Sporophore branching			Intercalary swellings
		A	B	C	
8	++	++	++	++	+
36	++	++	++	++	+
93	++	++	+	+	— to +
102	++	++	+	+	+
51	++	++	+	+	+
103	++	++	—	+	+
DAR 19881	++	++	+	+	+
DAR 25999	++	++	+	+	+
T240	++	++	+	+	+
3477	++	++	—	—	+
3392	++	++	+, ++	++	+
SC50	++	++	—	++	+
SC90	++	++	+, ++	++	—, +
DAR 37635	++	++	+	+	—
DAR 37636	++	++	+	++	—
DAR 37637	++	+, ++	—, +	++	—
DAR 37651	++	++	+, ++	+, ++	—
DAR 37656	++	++	+, ++	++	—
6210	++	++	+, ++	+, ++	—
6253	++	++	++	+, ++	—

A = sporophore unbranched
C = proliferation through the empty sporangium
++ = abundant

B = sympodial branching
— = none observed
+ = scarce

Table 4

*Mean value and range of length, breadth, length/breadth (L/B)
and pore diameter of sporangia of P. cinnamomi*

Strain No.	Length (L) (μ m)	Breadth (B) (μ m)	L/B	Pore diameter (P) (μ m)
8	50 (24-82)	35 (21-48)	1.4 (1.1-2.1)	9 (5-12)
36	52 (22-92)	35 (18-53)	1.5 (1.2-1.9)	9 (5-15)
93	45 (24-89)	31 (17-56)	1.5 (1.1-1.8)	10 (7-15)
102	61 (40-73)	46 (33-55)	1.3 (1.1-1.8)	10 (6-15)
51	52 (33-62)	39 (26-51)	1.3 (1.2-1.7)	10 (5-15)
103	57 (26-73)	46 (22-55)	1.3 (1.1-1.7)	10 (5-15)
DAR 19881	62 (29-81)	43 (27-55)	1.4 (1.1-2.1)	12 (5-18)
DAR 25999	55 (40-77)	39 (27-51)	1.4 (1.1-2.3)	9 (4-15)
T240	54 (37-81)	38 (26-55)	1.4 (1.2-1.8)	10 (7-15)
3477	51 (31-62)	38 (29-62)	1.4 (1.2-1.6)	10 (5-15)
3392	57 (48-70)	43 (33-53)	1.3 (1.2-1.5)	10 (6-15)
SC50	48 (31-71)	33 (26-44)	1.5 (1.1-2.2)	10 (5-15)
SC90	56 (37-77)	38 (26-48)	1.5 (1.2-1.7)	10 (6-15)
DAR 37635	48 (29-73)	36 (26-51)	1.3 (1.1-1.8)	9 (5-13)
DAR 37636	52 (35-71)	37 (26-48)	1.4 (1.2-1.8)	9 (7-15)
DAR 37637	59 (33-77)	39 (22-51)	1.5 (1.2-1.8)	11 (7-15)
DAR 37651	49 (37-66)	36 (26-48)	1.4 (1.1-1.9)	9 (6-12)
DAR 37656	53 (37-70)	37 (26-44)	1.4 (1.2-1.9)	9 (6-13)
6210	57 (33-84)	39 (18-55)	1.5 (1.1-2.0)	9 (5-12)
6253	56 (22-92)	37 (22-55)	1.5 (1.2-2.1)	9 (4-12)

Table 5

*Average growth rates (mm) of P. cinnamomi on V-8 agar with different concentrations
of malachite green, after 4 days at $25 \pm 1^\circ\text{C}$, in darkness*

Strain No.	Concentra- tions	1 : 2 000 000	1 : 4 000 000	1 : 8 000 000	1 : 12 000 000	1 : 16 000 000	No. mal- achite green (control)
8		7	9	17	20	25	59
36		3	14	23	22	23	61
93		13	11	22	22	23	64
T240		1	7	18	18	27	63
DAR 37635		1	12	14	15	16	52
DAR 37636		1	15	30	31	29	62
DAR 37637		3	7	22	37	39	52
DAR 37651		3	10	17	21	25	57
DAR 37656		3	11	23	26	28	58

OBSERVATIONS ON THE HYPHOMYCETES INHABITING FOREST LITTER OF HUNGARY

J. GÖNCZÖL and Á. RÉVAY

(Received: 15 January 1983)

Observations on aquatic Hyphomycetes and other Hyphomycetes inhabiting terrestrial forest litter are described. There was some similarity between the groups of Hyphomycetes growing on decaying leaves in streams and on terrestrial litter. 17 species of aquatic Hyphomycetes were detected, 14 of them by conidia only. Other Hyphomycetes whose habitats may be both aquatic and terrestrial are illustrated and discussed.

Introduction

In recent years numerous observations have been reported dealing with aquatic Hyphomycetes found in terrestrial environments (BANDONI 1972, PARK 1974*b*, DYKO 1976, WEBSTER 1977, SANDERS and WEBSTER 1978). Despite these reports, we have little data to prove in what form or in what quantities those species of Hyphomycetes supposed earlier to be aquatic can exist in terrestrial environments. The purpose of our observations was to look for these fungi in terrestrial habitats, near to where they had been studied earlier in water habitats. In addition to aquatic Hyphomycetes we present details of some other species of Hyphomycetes inhabiting terrestrial forest litter.

Material and method

The sites chosen for study were in the Börzsöny mountains along the Morgó-Szénpatak stream system as well as in SW Hungary (Zala County), where aquatic and other Hyphomycetes had earlier been studied (GÖNCZÖL 1971, 1975*a*, 1975*b*, 1976). Monthly collections in Börzsöny Mts. from Sept. 1979 and occasional collections in SW Hungary (Zala County) were made. Some data collected from earlier years are also added.

Samples were collected from terrestrial forest litter as well as from tree-hollows. Although tree-hollows may be considered as special aquatic habitats, we have nevertheless included them with terrestrial environments because of their intermediate position. Some species found in these hollows, were later also found on litter lying on soil.

The collected leaves were in various states of decomposition. The main part of the samples were skeletonized leaves collected from the lower layer of the litter which was usually moist. The remaining samples were partially degraded leaves collected from the upper part of the litter, which was usually somewhat dryer. None of these samples were collected from submerged habitats. The leaves collected from tree-hollows, were mostly skeletonized and sometimes submerged.

The samples were transported to the laboratory in plastic bags. In the laboratory the leaves were examined by two different methods: First, conidia detached from leaves were examined by use of a washing technic as well as interface examination (BANDONI 1972, WEBSTER 1977). In an other method wet leaves were incubated for various time in Petri-dishes, sometimes submerged. In addition to the incubation in Petri-dishes, parts of the leaves, mainly those which were highly skeletonized, were placed in little glass-boxes specially made for these observations. The boxes were made with a low (3 mm) sidewall attached to the slide, so that the leaves should be observed directly by microscope, without removing

them from their incubation site. The cultures were usually kept at cca. 10 °C, but some dishes were kept at room temperature. During the incubation, which was at least one month, the cultures were several times carefully scanned under dissecting and normal microscopes. We examined the meniscus and the bottom of the dishes, and the leaf skeletons, too.

In this paper we present species observed during our study in two parts. In the first part (I) of our enumeration we mention those species of which only detached conidia could be found by one of the spore detection methods. These species — except for one or two — are all conidia of species well known from the streams in the area, and belong to the Ingoldian Hyphomycetes. In the second part (II) are enumerated all those species which were collected from terrestrial litter and were seen growing and sporulating regardless of the fact that their sporulation went on in air or under submerged conditions.

Enumeration of species

I. Species 1–15 except for two, Nos 7 and 14 were collected in the Börzsöny Mts.

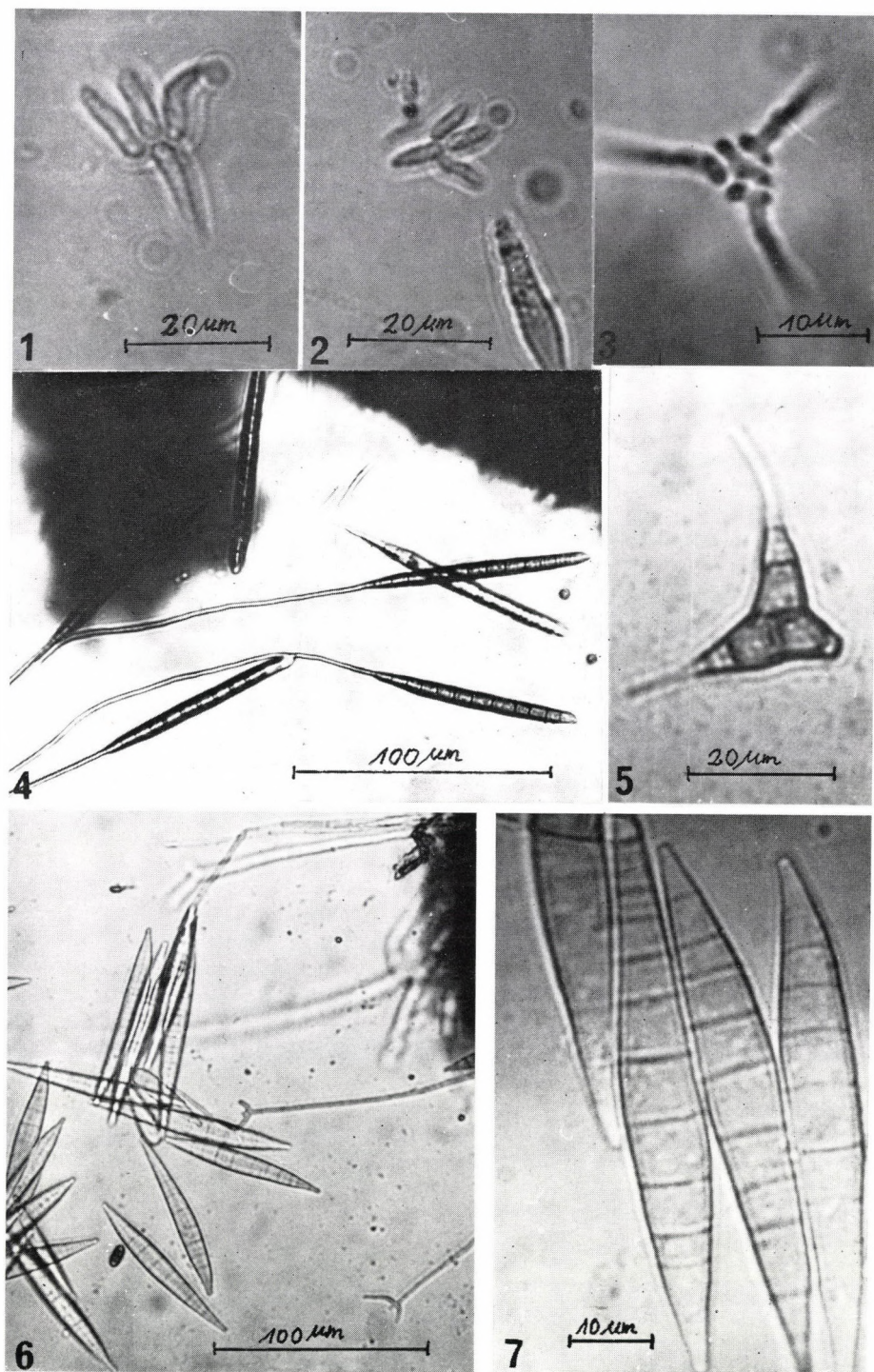
1. *Alatospora acuminata* Ingold. Numerous free conidia from litter samples through the year. Regularly found on beech and alder forest litter.
2. *Articulospora tetracladia* Ingold. Few free conidia from washed litter samples.
3. *Clavariopsis aquatica* de Wild. Some free conidia on only one occasion from washed litter samples.
4. *Dactylella aquatica* Ingold. On one occasion only two conidia from washed litter samples.
5. *Diplocradiella scalaroides* Arnaud (Plate I/5). A few conidia in a washed litter sample collected from alder litter. This species is well known from foam samples (INGOLD 1975a, GÖNCZÖL et TÓTH 1974), but we have never seen it growing on its substratum.
6. *Jaculispora submersa* Hudson et Ingold. Fairly frequent in washed litter samples, mainly in winter. One of the rarest species in the stream-spores of Hungary.
7. *Lateriramulosa uniinflata* Matsushima (Plate I/3). Rarely found in washed litter of beech forest on some occasions in Zala County. Conidia of this species occurred in two foam samples collected by TÓTH (1979b).
8. *Lemonniera aquatica* de Wild. Few free conidia mainly in winter samples.
9. *Lemonniera terrestris* Tubaki. Some free conidia found on only one occasion in a winter sample.
10. *Monotosporella tuberculata* Gönczöl. Rarely found as one or two conidia from washed beech litter, mainly in winter samples.
11. *Tetracladium setigerum* Grove. Free conidia found on several occasions from washed litter samples.
12. *Tricladium angulatum* Ingold. Few free conidia from washed litter samples.
13. *Tricladium splendens* Ingold. Some free conidia was found from washed litter samples.
14. *Varicosporium elodeae* Kegel. Found several times both from washed litter samples and tree-hollows in Zala County.
15. *Volucrispora ornithomorpha* (Trotter) Haskins (Plate I/1–2). Regularly found from washed litter. Not rare.

II.

16. *Beverwykella pulmonaria* (v. Beverwijk) Tubaki (Plate II/1–5)
syn.: *Papulaspora pulmonaria* v. Beverwijk.

Plate I

1–5. Detached conidia from washed litter: 1–2. *Volucrispora ornithomorpha* (Trotter) Haskins, 3. *Lateriramulosa uniinflata* Matsushima, 4. *Camposporium pellucidum* (Grove) Hughes. 5. *Diplocradiella scalaroides* Arnaud 6–7. *Dactylella rombospora* Grove

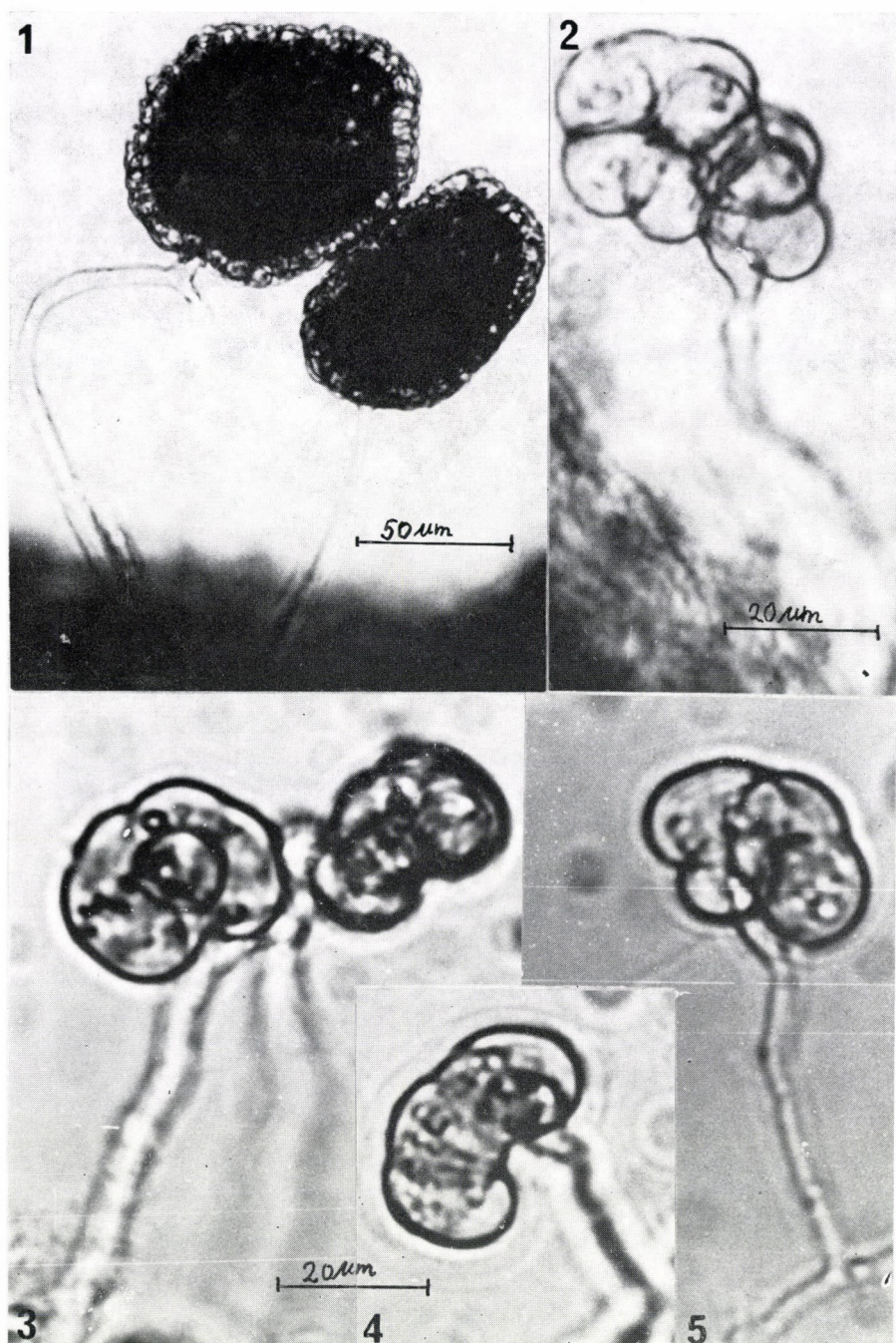


On one or two occasions a sporeball-like fungus with a blistered surface has appeared on decaying leaves collected both from forest-litter and tree-hollows. These unusual propagules (probably reproductive bodies of the fungus) were found amongst leaf petioles in wet or submerged conditions and consisted of aggregated masses of globular or multi-angular cells. The shape of the propagules was globose or somewhat flattened. The inner cells were dark-greyish, while the outer (marginal) ones were paler or nearly hyaline. These propagules were borne on straight or curved pale coloured, septate hyphae of various length. Their appearance seemed very like those illustrated by BEVERWIJK (1954) and TUBAKI (1975). The firm adhesion of the cells as well as the characteristic appearance of the propagules suggested that this fungus might be *Beverwykella pulmonaria*. On the same leaf-substrate we have seen several younger propagules, which probably belong to this fungus. These primordia were developing under submerged conditions. The matured propagules were 80–100 μm in diam. The cells of the young propagules were of various sizes, about 5–15 μm . Their shapes were globular, angular or lobed.

17. **Camposporium japonicum** Ichinoe. Conidia developed on decaying leaf-skeletons collected from a beech-forest near stream Szén-patak in the Börzsöny Mts., Sept. 1979, Oct. 1980. The occurrence of this fungus was much more rare than that of *Camposporium pellucidum*. It was found again on decaying alder leaves collected near stream Morgó-patak, Nov. 1982. Conidia were found very rarely in foam and water samples. They are cylindrical with a hyaline projection branching in three directions. Conidiophores growing out of leaves veins were rather scanty, pale brown, denticulate.
18. **Camposporium pellucidum** (Grove) Hughes (Plate I/4). This is a well-known Hyphomycetes inhabiting beech and alder litter. Usually this species was the first fungus to fruit on skeletonized leaves during incubation. Abundant sporulation was found in all litter samples collected through the year. It has been reported several times from various biotopes from Hungary (i.e. streams, tree-hollows, terrestrial litter). The conidia are pale or mid-brown, cylindrical-fusiform, 60–100 \times 5–6 μm , usually prolonged apically into a pale or hyaline projection, which is sometimes up to 260 μm long.
19. **Dactylaria ampulliformis** (Tubaki) Bhatt et Kendrick. Conidia which were somewhat ampulliform were seen in several washed litter samples. Abundant sporulation of the fungus was observed on decaying alder litter collected from the banks of Morgó-stream Börzsöny Mts., Oct. 1982, when incubated for two weeks. This species is identified with *Dactylaria ampulliformis* only with reservation, because of the different appearance of the conidia. The hyphae are hyaline 2–3 μm wide, and give use to hyaline unbranched, straight conidiophores of various length (up to 50 μm) with numerous denticles at the apex. Conidia hyaline, rather fusiform then cylindrical, 1–3 septate. The constrictions at the upper septum are not so marked as those illustrated by TUBAKI (1958). Moreover the remarkably fusiform shape of the conidium which tapers gradually towards its apex gives a different shape to the conidium. The upper cell of the conidium is always inaequilaterally asymmetrical. Consequently our conidia appear less ampulliform than those of TUBAKI. A further difference is that one part of the conidium is bent at the upper septum (at the constriction) usually at an angle of 135°. In addition to this conidium-type we find conidia with straight projections, too, without any widening at the base of the projection. Conidia are somewhat longer than those reported by TUBAKI (1958) and MATSUSHIMA (1975), usually between 40–50 μm ; only a few conidia are about 30 μm long. The width of the

Plate II

1–5. Propagules of *Beverwykella pulmonaria* (v. Beverwijk) Tubaki: 1. Matured propagules growing on decaying leaf, 2–5. Young submerged propagules growing on decaying leaf



conidia 2.5–3.5 μm and the projection at the broadest part is 1.5–1.8 μm wide. Although these differences in the appearance of the conidium are well-marked we found them insufficient to justify segregating this fungus from *Dactylaria ampulliformis*.

20. *Dactylella rhombospora* Grove (Plate I/6–7). Litter samples containing mainly alder leaves were collected in Börzsöny Mts., Jan. 1982. The majority of the alder leaves were decaying

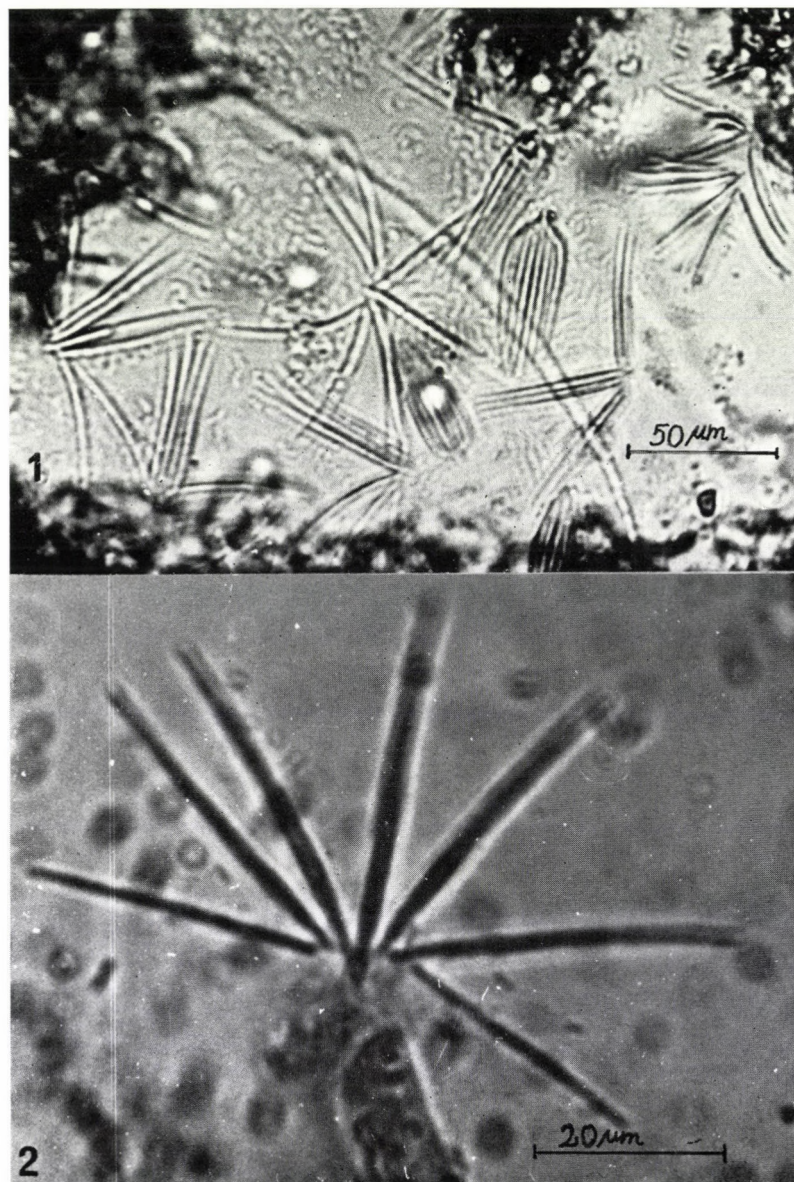


Plate III

1–2. Detached conidia of *Magdalaenaea monogramma* Arnaud on decaying beech leaf

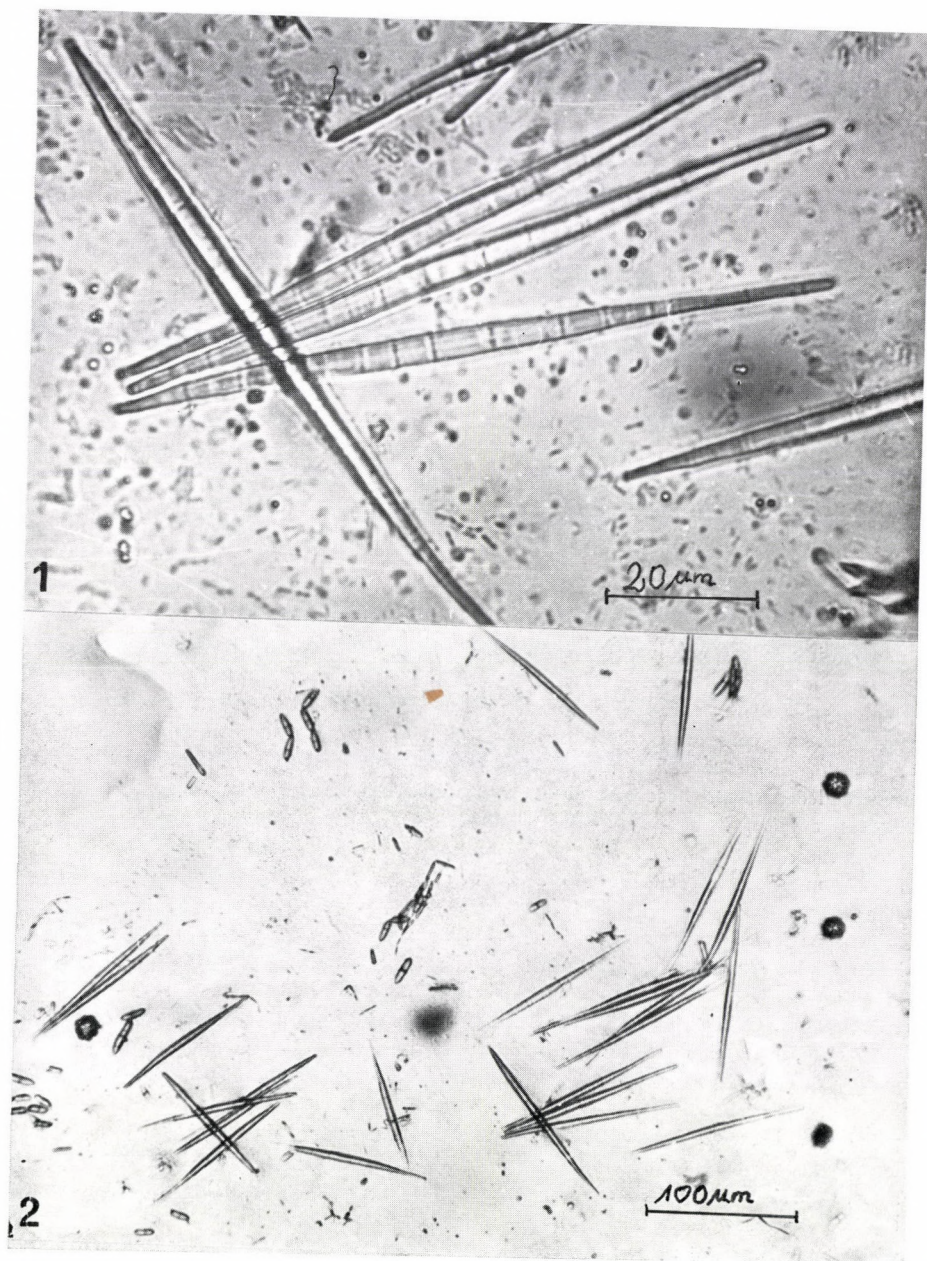


Plate IV

1-2. Detached conidia of *Mirandina corticola* Arnaud from litter leaves

but not skeletonized. The leaves were kept moist in Petri-dishes and after three weeks incubation colourless, loose mycelium was spread over the surface of the leaves.

Conidiophores hyaline, straight, erect, at the base 4–5 μm wide, shortly branched and 2–3 μm wide at the tip. Conidium initials clavate fusoid at first (rarely they remain this shape at maturity, too) but much more frequently the spindle-shape is the characteristic. On its natural substrate the length of the conidia was 80–90 μm , somewhat longer than those reported DRECHSLER (1937), but agreeing well with those of MATSUSHIMA (1975). The width of the conidia were 9–10 (11) μm , usually with 10 cross-walls.

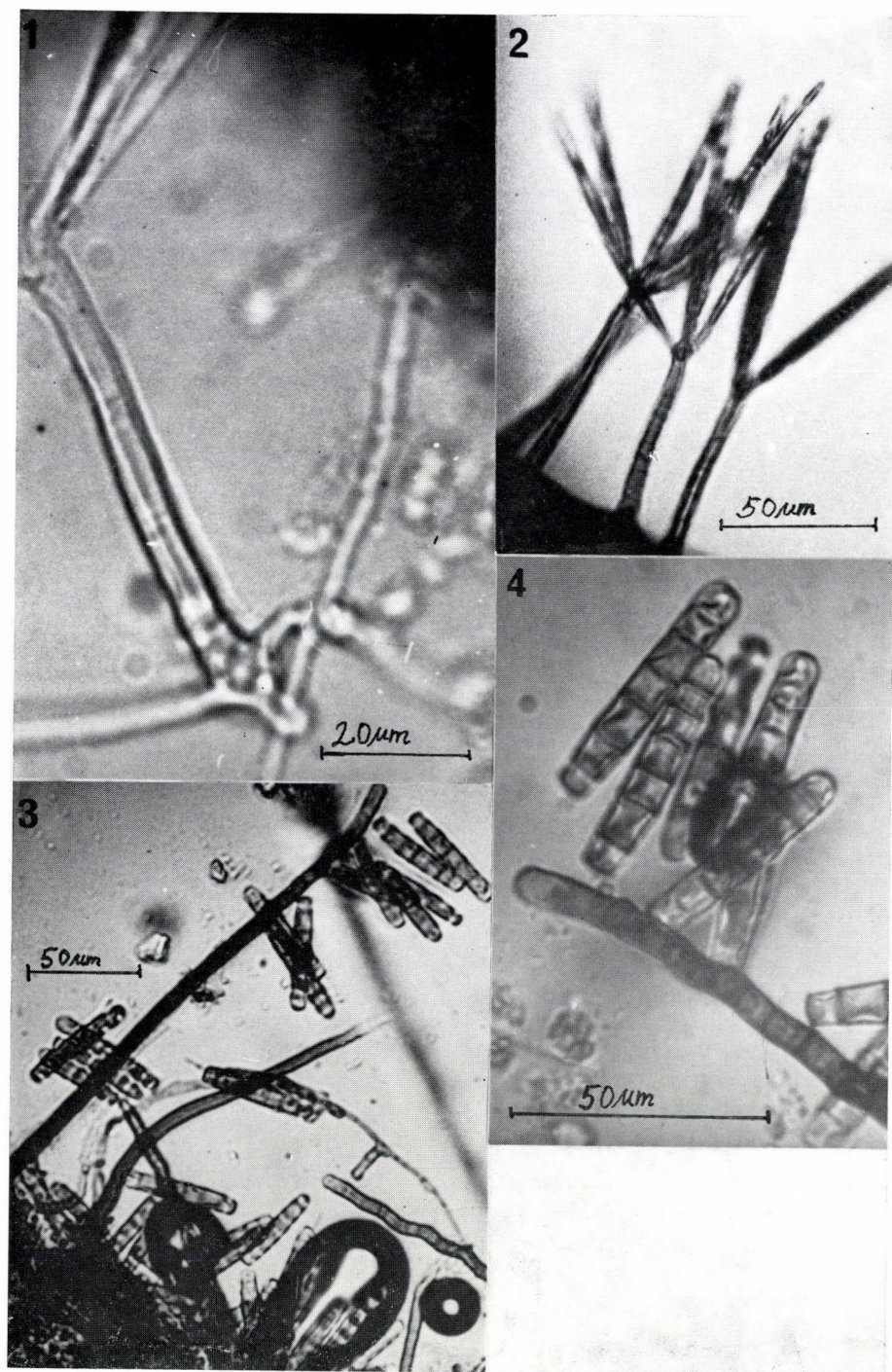
21. *Dactylella submersa* (Ingold) Nilsson. Sporulating rather scanty on decaying alder leaves on one occasion. Repeatedly found on decaying beech skeletons collected from tree hollows (GÖNCZÖL 1976).
22. *Dimorphospora foliicola* Tubaki (Plate VI/4–5). On some occasions sporulating on decaying leaves collected both from terrestrial litter and tree-hollows. (Zala County 1976, Börzsöny Mts. 1979.)
23. *Endophragmia alternata* Tubaki et Saito (Plate V/3–4). Greyish colonies of the fungus were grown on the strobili of alder (*Alnus pluinosa*). Strobili were found amongst litter collected in Börzsöny Mts. Apr. 1981, picked up and separated from the leaves and kept moist in Petri-dishes. The first colonies appeared after one month incubation on the stalk of the strobilus. Conidiophores solitary, rather dark brown, smooth, annellate, together with the fertile part 150–200 μm long, 5–7 μm thick. Conidia pale brown, cylindrical, truncate at the base rounded at the apex, 35–50 \times 5–8 μm . It was observed that conidia often remained attached to the conidiophore for some time (cf.: ELLIS 1976), however a new conidium formed always terminally.
24. *Magdalaenaea monogramma* Arnaud (Plate III/1–2). Abundant sporulation was found at one occasion on a beech leaf-skeleton, collected Sept. 1974, Börzsöny Mts., and incubated for a year in refrigerator. The leaf-skeleton was held submerged in a Petri-dish. It was found once again as a single conidium in a washed litter sample, Sept. 1979. Both samples were collected from beech forest litter. Conidia have never been seen in foam samples in Hungary.

Main axis 40–50 \times 2–2.5 μm , extending at the apex into pointed, lateral branches 30–40 μm long, two or three on each side. On one or both sides one of the branches is a secondary one.

25. *Mirandina corticola* Arnaud (Plate IV/1–2, Plate V/1–2). In the sediment of several litter-leaf samples straight, highly septate, hyaline conidia, rather pointed at both end were often seen. Also they were seen on several occasions in the water-samples collected from tree-hollows. On some beech leaf skeletons collected from a tree-hollow in Zala County, Dec. 1976, numerous pale brown, conidiophores grew out. Conidiophores arose single or in groups directly from the colourless, 2–3 μm wide, erect, straight or flexuous, cylindrical hyphae, not or hardly tapering towards the apex. The lower part of the conidiophore is pale or mid brown, thick-walled, upper part pale brown or hyaline and thin-walled, smooth, usually 2–4 septate, 60–80 μm long, 4–5 μm wide at the base, hardly tapering towards the apex. Conidia borne at the ends of short denticles on the hyaline tip of the conidiophore. Conidia are elongate fusiform (spear-shaped), hyaline, 90–120 μm long, usually 3 μm (4) wide at the broadest part, gradually tapering towards each end, rather frequently septate (12–15 septa). Usually 3–6 conidia can be seen on the tip of the conidiophore.

Plate V

1. Conidiophore of *Mirandina corticola* growing on decaying leaf
2. *Mirandina corticola*: conidiophores with attached conidia
- 3–4. *Endophragmia alternata*: conidiophores with detached conidia



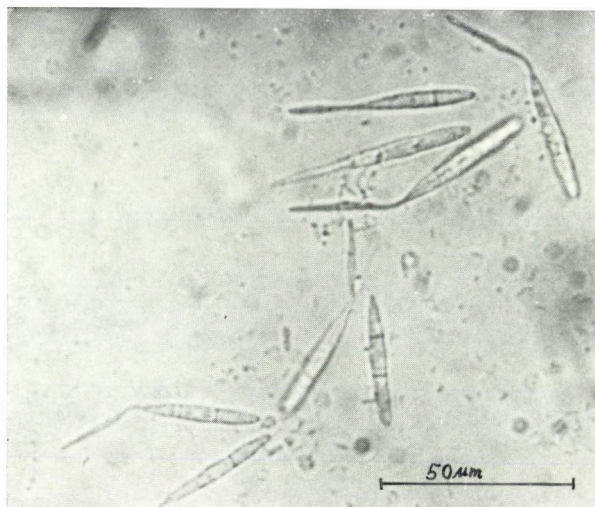


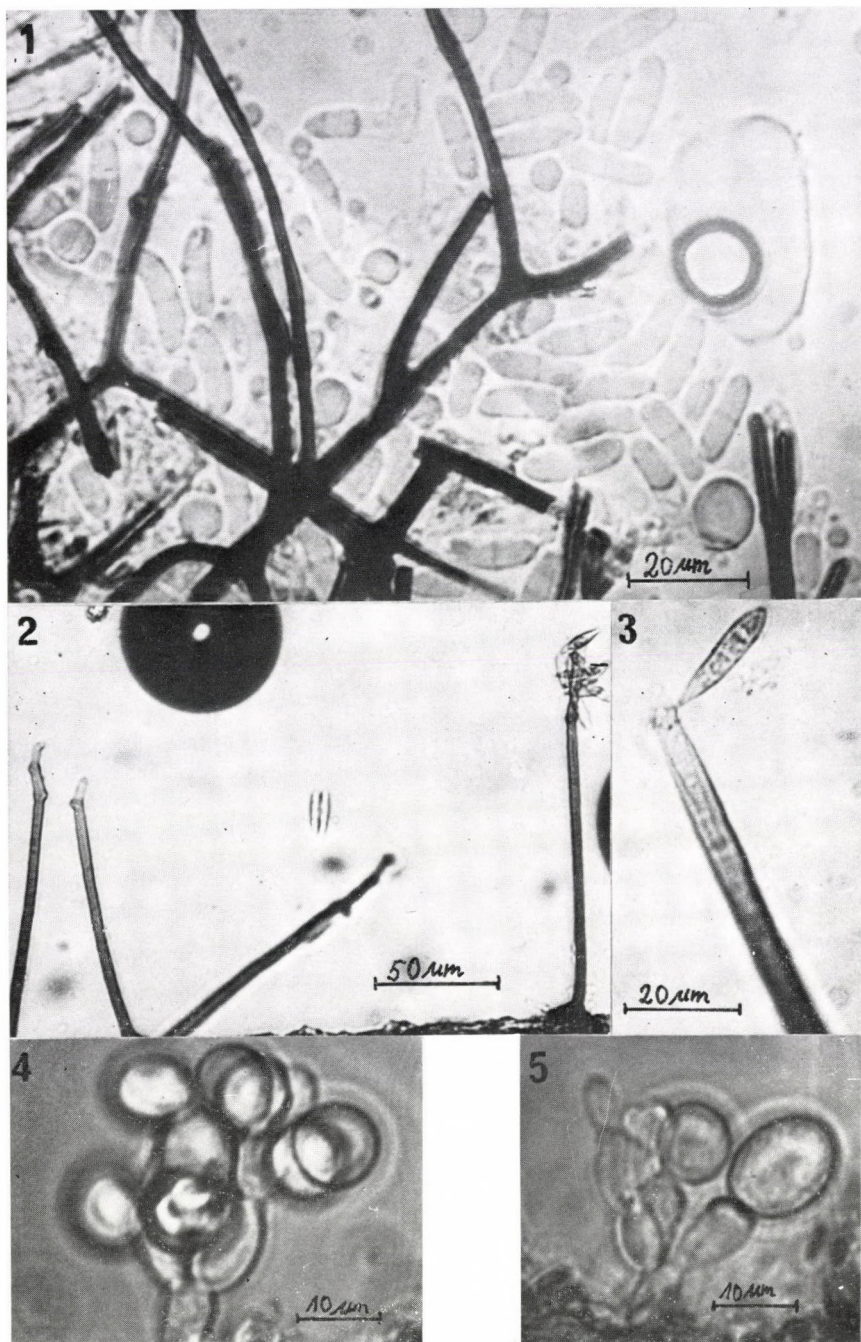
Fig. 1. Detached conidia of *Dactylaria ampulliformis*

The fungus repeatedly occurs on decaying leaves collected both from water (i.e. tree-hollows) and terrestrial litter. Its behaviour somewhat resembles to aero-aquatic Hyphomycetes. Sporulation usually starts when the water surface is lowered, and the leaf substrate extends into the air. The mycelium and the base of the conidiophore remain in the water but conidia are in the air. Also it was observed several times that after total drying of the substratum when the material was wet again, abundant sporulation soon started. It is very likely that conidia illustrated by INGOLD (1975b, Fig. I/7) and collected from foam-samples of West-Scotland belong to this species.

26. *Neta patuxentica* Shearer et Crane (Plate VI/1). This fungus was first time reported from Hungary by TÓTH (1975) on dung. Our observations show that this fungus appears fairly frequently on litter but in early stages of the decay. All of our finds were on brown dead leaves (*Quercus* spp.), but they were not or hardly skeletonized. Litter samples were kept in Petri-dishes with enough water to keep them moist. Colonies of the fungus formed after rather long (1–3 months) incubation. Colonies 400–800 μm in diam, consist of a loose, black net with a white, splendid spore mass in its centre. Conidia hyaline, 1-septate, slightly curved, $13\text{--}16 \times 4\text{--}5 \mu\text{m}$. All our collections are from forest-litter of Börzsöny Mts., Mai 1981, July 1982.
27. *Pleurophragmium parvisporum* (Preuss) Hol.-Jech. (Plate VI/2–3). Debris of litter-leaves collected from Börzsöny Mts. Jan. 1982, was kept moist in Petri-dishes. After three weeks incubation little groups of conidiophores were seen on the pieces of the leaves. Conidiophores were straight, erect, dark brown at the base and paler towards their tip, nearly hyaline at the tip. Some of them were cylindrical and others tapered gradually from the base ($4.5\text{--}5.5 \mu\text{m}$) towards the tip ($3 \mu\text{m}$). Conidia developed on the pale brown or hyaline upper part of the conidiophores on short denticles. The basal ends of the conidia were

Plate VI

1. *Neta patuxentica*, part of the colonie with conidia
- 2–3. *Pleurophragmium parvisporum*, conidiophores with conidia
- 4–5. *Dimorphospora foliicola* sporulating on decaying leaf



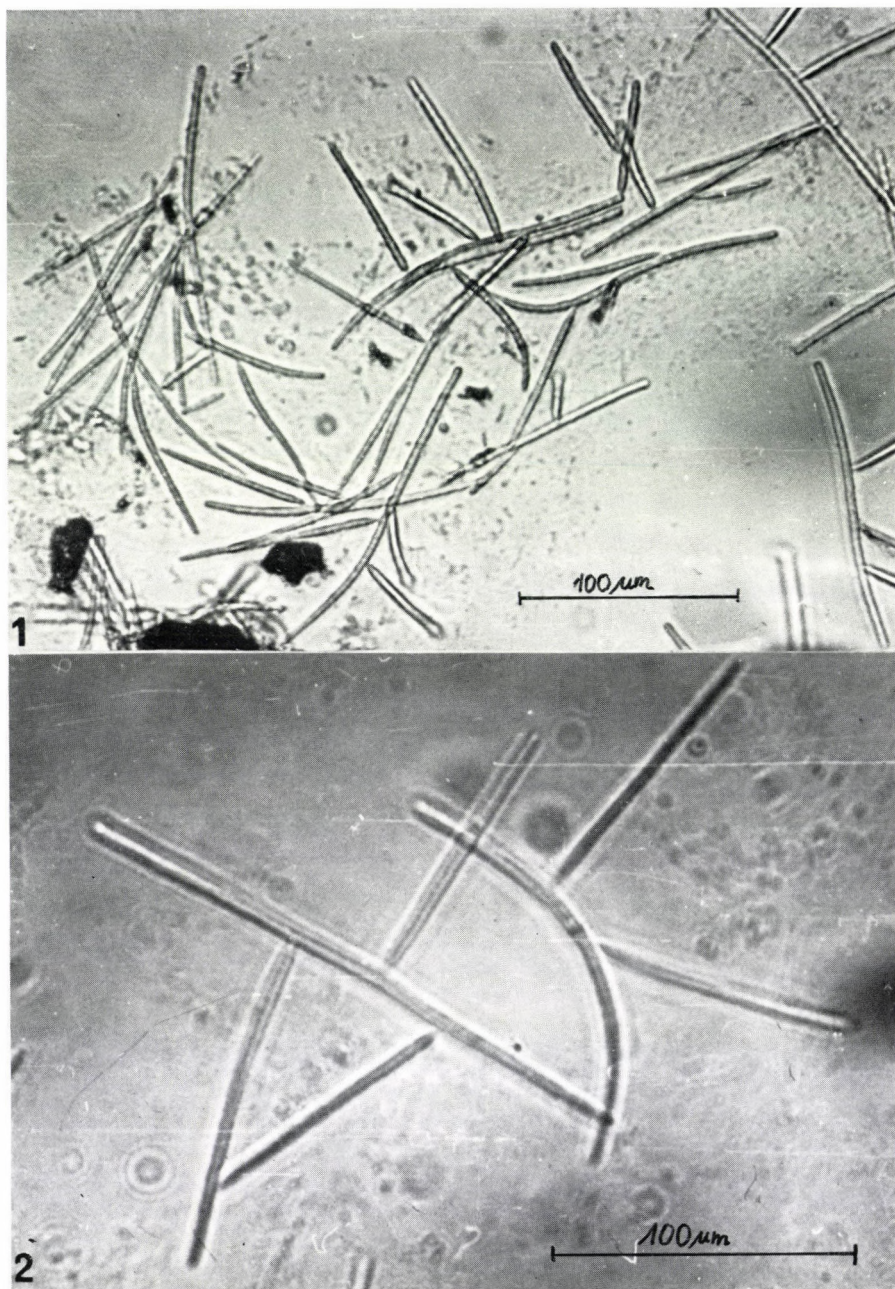


Plate VII

1-2. *Tricladium* sp., detached conidia from litter samples

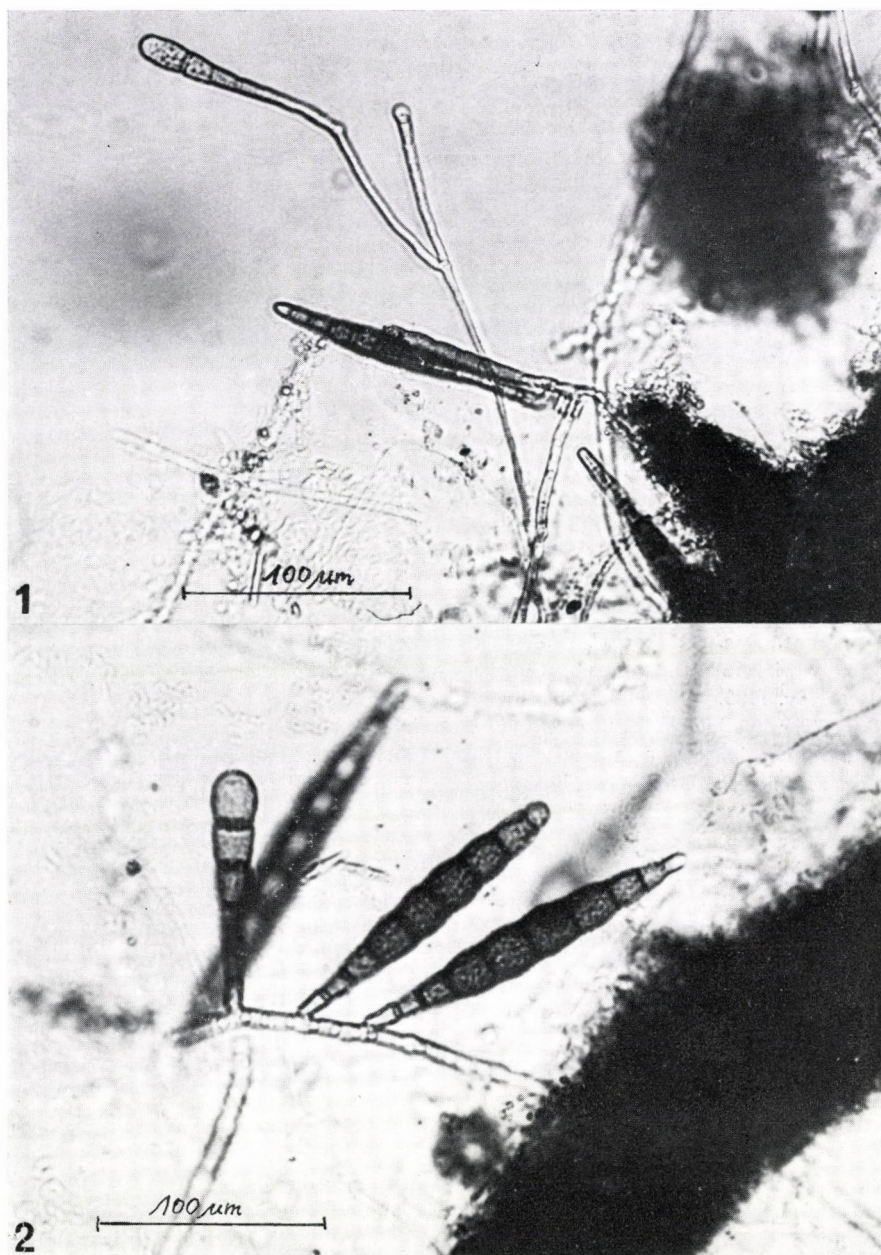


Plate VIII

1-2. *Vargamyces aquaticus*, conidiophores with attached conidia growing on submerged leaf skeleton

pointed, the apical one more or less blunt or rounded, pale yellow some of them nearly hyaline. The majority of the conidia had three septa. They measured $20-25 \times 4-6.5 \mu\text{m}$.

28. *Pseudodictyosporium* sp. (Plate IX/1-2). The fungus appeared on decaying but not skeletonized alder leaves collected near the stream Morgé-patak, Börzsöny Mts. Sept. 1982, after one month incubation. The fungus was seen first as semi-globose sporodochia with a silvery surface in the light. Conidia muriform, divided by two longitudinal and 2-4 transverse septa. The longitudinal septa divide the conidium into three sections and each of the sections are further divided by transverse septa. Conidia more or less elliptical or cordate, yellowish-brown, flattened, one cell thick, $18-22 \times 13-16 \times 7-8.5 \mu\text{m}$ measured. The shape and structure of the conidia are very similar both to conidia of *Berkleasmium leonense* M. B. Ellis (ELLIS 1976) and of *Pseudodictyosporium wauense* Matsushima (MATSUMISHIMA 1975) but the fungus differs from both in its conidiogenesis.

Later we found an other appearance of the fungus, lacking sporodochia. Loose groups of long ($100-300 \times 2-3 \mu\text{m}$) conidiophores were seen on the surface of the substrate, as described in the case of *Pseudodictyosporium wauense*. However the present fungus produced conidia on the apex of the conidiophores not only singly but in pairs, too. Further study is being made on this species to clarify its behaviour.

29. *Tetrachaetum elegans* Ingold. Sporulating on sparse conidiophores on decaying beech leaves collected from forest litter, in Börzsöny Mts., Dec. 1979.
30. *Tricladium* sp. (Plate VII/1-2). The conidia of this fungus are known from water samples collected from tree-hollows in SW-Hungary (GÖNCZÖL 1976). It has also been collected from various litter samples on several occasions in Zala County (1976) and in Börzsöny Mts., Sept., Dec. 1979, Oct. 1982. Most recently this fungus has been found again. Conidia were growing in little groups on the surface of soil without any plant remains, Börzsöny Mts., Nov. 1982.

The hyaline conidium consists of a straight or slightly curved axis, $100-200 \times 3-4.5 \mu\text{m}$, from which two or three lateral branches, $40-80 \times 3-4 \mu\text{m}$, grow out. Neither the main axis nor the laterals hardly taper from the basal cell to the tip. The lateral branches originate from the main axis at well defined constrictions.

Conidiophores rather short, $10-30 \times 3 \mu\text{m}$, usually definitely curved, unbranched. The conidia are very like those illustrated by INGOLD (1975a, b) from foam samples, collected in England and Wales and identified as *Tricladium terrestre* Park. Our *Tricladium* sp. differs from *T. terrestre* (Park in litt.): 1. "in the absence of secondary branches", 2. "the main axis and laterals do not taper much from the basal cell to the tip", 3. "the conidia of *T. terrestre* are consistently larger" than ours.

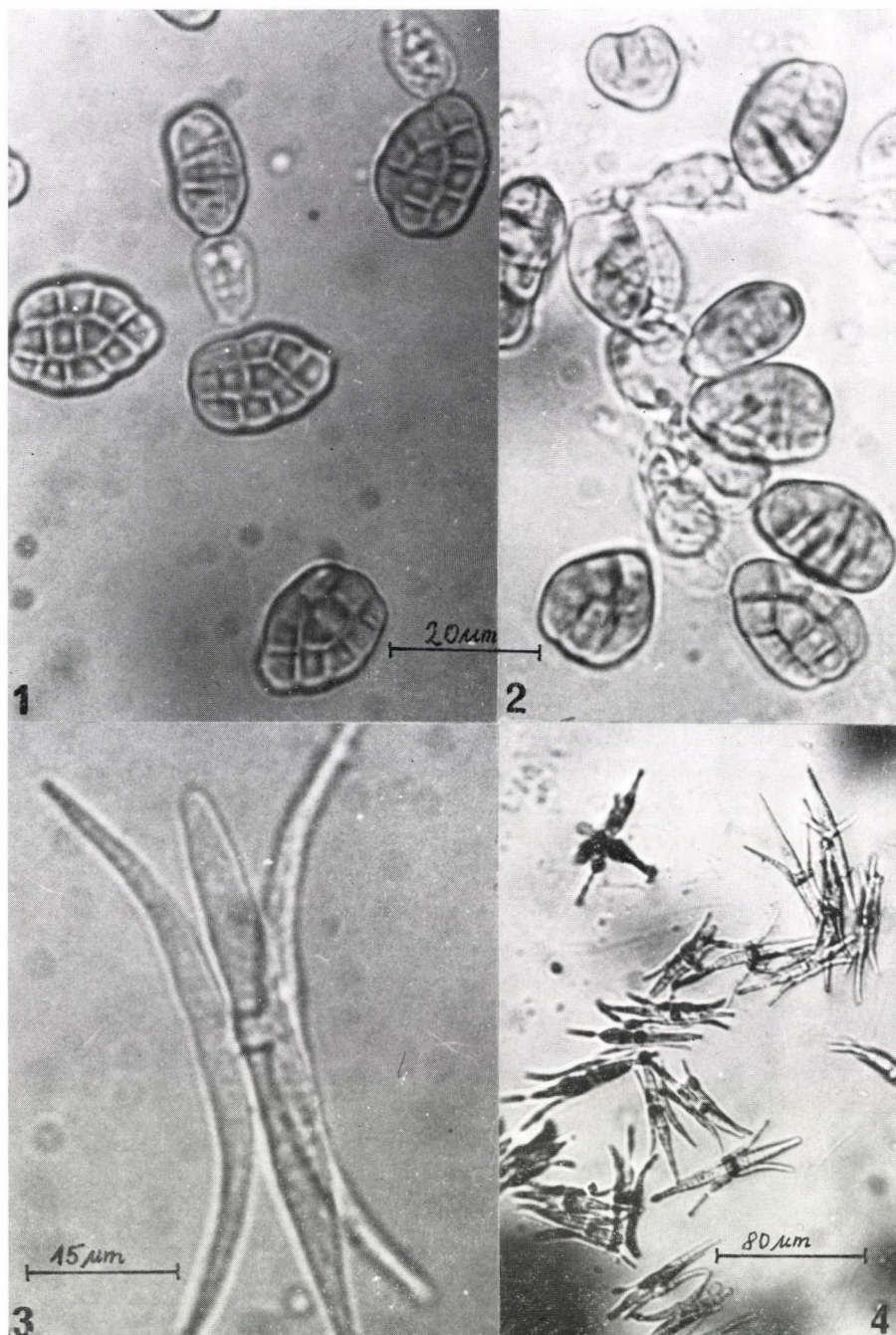
This fungus also behaved like *Mirandina corticola*; i.e. after several months drying of the leaf-skeleton substrate abundant sporulation started soon after re-wetting.

31. *Vargamyces aquaticus* (Dudka) Tóth (Plate VIII/1-2) syn.: *Camposporium aquaticum* Dudka.

DUDKA's fungus was re-disposed by TÓTH (1979a) and detailed ecological observations were reported. The fungus is commonly found on various decaying leaves collected from forest litter, not only submerged but in rather dry conditions also. It was found more frequently in autumn and winter samples but was present through the year. Usually abundant sporulation was observed not only on decaying deciduous leaves, but on

Plate IX

- 1-2. *Pseudodictyosporium* sp., young and matured conidia from sporodochium
3-4. Unidentified: 3. Young, detached conidium under water; 4. Detached conidia floating on water surface



- herbaceous plant material too. Uncommon in foam samples. The large fusiform, brown or dark brown conidia were rather obtuse at both ends and measured $80\text{--}160 \times 15\text{--}20\text{ }\mu\text{m}$.
32. **Unidentified** (Plate IX/3–4). In a litter sample of Sept. 1982, collected near the stream Morgó-patak, Börzsöny Mts., sixbranched conidia of an unidentified fungus were seen floating on the water surface. The conidia somewhat resembled in structure those reported and illustrated by GÖNCZÖL (1971, Table I, Figs 21–22), and INGOLD (1975a, p. 91, Figs 39,5). Conidium hyaline, consisting of a long cylindrical-fusiform axis to which a H-shaped branch is attached by a short connection. The axis is $80\text{--}100\text{ }\mu\text{m}$ long, $5\text{--}6\text{ }\mu\text{m}$ wide in the middle, tapering gradually to both the basal and apical ends, generally with 5–10 septa. The H-shaped branches are sometimes developed more or less parallel to the axis but sometimes they are rather bent.

Complete development of conidia was observed on skeletonized alder leaves incubated in a very thin water layer. Further studies are necessary to clarify the generic classification of this fungus.

Discussion

In this paper we did not wish and were unable to decide which species are aquatic and which terrestrial. We wanted to get as complete a picture as possible about those species of Hyphomycetes inhabiting forest litter in an area where the aquatic Hyphomycetes of the streams have been well known for some ten years.

It was expected from data reported in several papers, that we might meet species of Hyphomycetes well known from water habitats. Although this paper is only the first part of the observations aimed at gathering data and the observations are rather preliminary, we could find little similarity between the composition of species of Hyphomycetes inhabiting decaying leaves, collected from streams, and terrestrial litter.

Although the numbers of spores detected in these observations were not great, conidia of aquatic Hyphomycetes were discovered in nearly all litter samples collected from various part of forest litter. Nevertheless, the number of conidia were always very low whichever method of detecting the spora was employed. On the other hand however, we could find species which were very rare or not previously known in water environments in Hungary. These included: *Dimorphospora foliicola*, *Jaculispora submersa*, *Lateriramulosa uniinflata*, *Volucrispora ornithomorpha*. *Lateriramulosa uniinflata*, detected by its free conidia only, seems to be a more frequent species in terrestrial litter than in foam samples (TÓTH 1979).

We could find all 17 species of aquatic Hyphomycetes from terrestrial litter. Of the 17 species 14 were found only as detached conidia washed from leaves.

Concerning aquatic Hyphomycetes the observations on litter leaves incubated for various time showed more scanty results. In all, three species,

Tetrachaetum elegans, *Dimorphospora foliicola* and *Dactylella submersa* could be found growing and producing conidia on litter leaves kept in submerged condition. Of the three species *Dimorphospora foliicola* has not been previously found from water or terrestrial habitats in Hungary.

All the three species were seen with sparse conidiophores. Although our observations have been made continuously for many years and the incubation of litter leaves has been repeated several times, we have been unable to find further species of aquatic Hyphomycetes. We think therefore that these observations confirm the suppositions that the activity of the species of aquatic Hyphomycetes well known from water habitats may be rather restricted in terrestrial litter, as stated by SANDERS and WEBSTER (1978).

At the same time, however, vigorous activity of other Hyphomycetes could be observed in almost all litter samples incubated either in wet or submerged conditions. Therefore we wanted to obtain information on some of the representatives of the Hyphomycetes inhabiting mainly beech and alder litter. The majority of these fungi are obviously terrestrial species, and their behaviour shows some resemblance to those of aquatic or, at least, to water-borne species. Short comments on the more remarkable species of the fungi observed may be of interest.

It is a well-known fact (INGOLD 1975) that spore production of *Camposporium pellucidum* goes on submerged condition, too. In our terrestrial litter samples underwater sporulation of the fungus was observed on numerous occasions. This species was also usually the first to emerge with abundant sporulation among the Hyphomycetes colonising highly decayed leaves. Similar behaviour, but with less abundant underwater sporulation was seen in *Camposporium japonicum*. The appearance of *Vargamyces aquaticus* was rather frequent usually with submerged, but sometimes with aerial sporulation. Two species (*Tricladium* sp., *Mirandina corticola*) behaved like each other; both species appeared after total drying of their leaf-skeleton substratum and they were able to produce conidia under both submerged and aerial conditions.

The most remarkable fungus was undoubtedly the species listed under No. 32 which may be considered an aquatic one, though its substrate (decaying leaves) may be collected from moderately moist terrestrial litter. Nevertheless the fungus showed a complete aquatic behaviour: any part of the fungus growing under water, produced and liberated conidia whilst in the submerged condition. Abundant and recurrent sporulation was observed during several weeks incubation.

In the cases of the species mentioned above we could not define exactly the submerged condition. We found that these species could find submerged conditions even if the water layer was very thin (some hundred μm) among the leaf veins. It seems that this very thin layer of water could be sufficient to ensure submerged conditions for certain fungi.

The observations support the supposition that some Hyphomycetes on litter leaves may be in closer contact with the water environment, than is the case with true terrestrial species. On the other hand the water conditions in terrestrial litter may be more variable than in true aquatic environments and these conditions could be preferred by certain species of aquatic Hyphomycetes.

ACKNOWLEDGEMENTS

The authors are grateful to Professor J. WEBSTER for kindly reading and criticising the manuscript and for his useful suggestions.

REFERENCES

- Arnaud, G. (1952): Mycologie Concrète: Genera. *Bull. Soc. Mycol. Fr.* **68**: 205.
- Bandoni, R. J. (1972): Terrestrial occurrence of some aquatic hyphomycetes. *Canadian Journal of Botany* **50**: 2283–2288.
- Beverwijk, A. L. van (1954): Three new fungi: *Helicoon pluriseptatum* n. sp., *Papulaspora pulmonaria* n. sp. and *Tricellula inaequalis* n. gen., n. sp. *Anton Leewenh.* **20**: 1–16.
- Drechsler, C. (1937): Some Hyphomycetes that prey on free-living terricolous Nematodes. *Mycologia* **29**: 447–552.
- Dyko, B. J. (1976): A preliminary study of aquatic Hyphomycetes on leaves in forest and stream litter. *J. Tennessee Acad. Sci.* **51**: 7–8.
- Ellis, M. B. (1971): *Dematiaceous Hyphomycetes*. Commonwealth Mycol. Inst., England, 608 pp.
- Ellis, M. B. (1976): *More Dematiaceous Hyphomycetes*. Commonwealth Mycol. Inst., England, 507 pp.
- Gönczöl, J. (1971): Aquatic Hyphomycetes from the Mts. Börzsöny. *Ann. Hist. Nat. Mus. Hung.* **63**: 57–75.
- Gönczöl, J. (1975a): Ecological observations on the aquatic Hyphomycetes of Hungary, I. *Acta Bot. Acad. Sci. Hung.* **21**: 243–264.
- Gönczöl, J. (1975b): *Monotosporella tuberculata*, a new species of Aquatic Hyphomycetes from Hungary. *Nova Hedwigia* **27**: 493–500.
- Gönczöl, J. (1976): Ecological observations on the Aquatic Hyphomycetes of Hungary, II. *Acta Bot. Acad. Sci. Hung.* **22**: 51–60.
- Gönczöl, J., Tóth, S. (1974): Rare or interesting conidia from streams of Hungary. *Bot. Közlem.* **61**: 57–75.
- Holubova-Jechova, V. (1972): A note on *Pleurophragmium simplex* (Hyphomycetes). *Česka Mykologie* **26**: 223–225.
- Haskins, R. H. (1958): Hyphomycetes fungi: *Volucrispora aurantiaca* n. gen., n. sp., *V. ornithomorpha* (Trotter) n. comb., and emended. *Can. J. Microbiol.* **4**: 273–285.
- Ingold, C. T. (1975a): An illustrated guide to aquatic and waterborne Hyphomycetes (Fungi imperfecti) with notes on their biology. *Freshwater Biol. Ass. Ambleside, Sci. Publ.* No. **30**: 1–96.
- Ingold, C. T. (1975b): Conidia in the foam of two English streams. *Trans. Br. mycol. Soc.* **65** (3): 522–527.
- Marvanova, L. (1973): Notes on *Lateriramulosa uniinflata*. *Trans. Br. mycol. Soc.* **60** (1): 145–165.
- Matsushima, T. (1975): *Icones microfungorum*. Japan, 209 pp., 415 pls.
- Miura, K., Okano, S. (1979): *Lateriramulosa quadriradiata*, a new aquatic Hyphomycete. *The Journal of Japanese Botany* **54** (7): 204–210.
- Park, D. (1974a): *Tricladium terrestre* sp. nov. *Trans. Br. mycol. Soc.* **63**: 179–183.
- Park, D. (1974b): Aquatic Hyphomycetes in non-aquatic habitats. *Trans. Brit. mycol. Soc.* **63**: 183–187.
- Sanders, P. F., Webster, J. (1978): Survival of aquatic Hyphomycetes in terrestrial situations. *Trans. Br. mycol. Soc.* **71**: 231–237.
- Shearer, C. A., Crane, J. L. (1971): Fungi of the Chesapeake bay and its tributaries. I. Patuxent River. *Mycologia* **63**: 237–260.

- Thakur, S. B. (1977): Survival of some aquatic hyphomycetes under dry conditions. *Mycologia* **69**: 843–845.
- Tóth, S. (1975): Rare microscopic fungi from Hungary. *Bot. Közlem.* **62**: 13–18.
- Tóth, S. (1979a): *Vargamyces*, a new genus of Hyphomycetes on submerged plant debris. *Acta Bot. Acad. Sci. Hung.* **25**: 403–410.
- Tóth, S. (1979b): A vízi Hyphomycetes és társgombái Magyarországon (Aquatic Hyphomycetes and their accompanied fungi in Hungary). Candidate dissertation.
- Trotter, A. (1904): Notulae mycologicae. *Ann. Mycol.* **2**: 533–538.
- Tubaki, K. (1958): Studies on the Japanese Hyphomycetes. V. Leaf and stem Group with a Discussion of the Classification of Hyphomycetes and their Perfect Stages. *J. Hattori Bot. Lab.* **21**: 142–244.
- Tubaki, K. (1975): Notes on the Japanese Hyphomycetes. VI. *Candelabrum* and *Beverwykella* gen. nov. *Trans. of Mycol. Soc. of Japan* **16**: 132–140.
- Webster, J. (1977): Seasonal observations on “aquatic” Hyphomycetes on oak leaves on the ground. *Trans. Br. mycol. Soc.* **68**: 108–111.

DISJUNCT HEPATICAE IN TROPICAL AMERICA AND AFRICA

S. R. GRADSTEIN,¹ T. PÓCS² and J. VÁŇA³

¹INSTITUTE OF SYSTEMATIC BOTANY, UNIVERSITY OF UTRECHT, NETHERLANDS

²RESEARCH INSTITUTE FOR BOTANY, HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT, HUNGARY

³DEPARTMENT OF CRYPTOGRAMIC BOTANY, CHARLES UNIVERSITY, PRAHA, CZECHOSLOVAKIA

(Received: 1 February 1983)

Keywords: Africa, America, disjunction, dispersal, Hepaticae, plate tectonics, phyto-geography, taxonomy, vicariants

An increasingly large number of macrodisjunct species is emerging from recent literature dealing with taxonomy and floristics of tropical bryophytes. This paper reviews present knowledge concerning Afro-American disjunctions in Hepaticae and seeks to interpret the data in the light of current phytogeographical theory. Numerous new floristic records and range extensions are given and some taxonomic novelties are proposed. For 35 Afro-American species known three main distribution types are recognized, each further subdivided: Tropical Afro-American (lowland, montane and the alpine element), Subtropical-Mediterranean (southern, wide element) and Temperate-Subantarctic (southern, wide element). Most species belong to Jungermanniales except for the subtropical ones which are thallose. A few Afro-American genera, including the "peri-Afroamerican" *Symbiezidium* and *Bryopteris*, and vicariant species-pairs are also discussed. Among tropical taxa, lowland patterns are normally continuous, while montane and alpine patterns are typically "quadricentric" resp. "bicentric". Deviating patterns may due to insufficient exploring or taxonomic knowledge, or relict nature. Several species are "weedy" and in the possession of excellent dispersal capacities; their occurrence in other palaeotropical regions is to be expected as well. Interpretation of dispersability is hampered, however, by the lack of experimental data on spore viability in liverworts (as contrary to mosses). It is postulated that macrodisjunct Afro-American species ranges in most cases should have arisen from successful transoceanic long-range dispersal whereas generic disjunction and species vicariance might be the result of ancient land connections, viz. evolution following the dissection of western Gondwanaland.

Introduction

"The phenomenon of disjunct taxa has long fascinated phytogeographers and taxonomists, and few questions have been more discussed by various groups of botanists in recent decades" (LÖVE 1967: 331).

In the 19th century there was a common belief, that the distribution of bryophyte species and of other spore plants was often world-wide (see e.g. Synopsis Hepaticarum, 1844-47). Later, the idea that bryophyte species are normally restricted to continents or smaller regions, became more widely accepted and led i.a. to an enormous increase in the number of described species (e.g. STEPHANI 1898-1924). In the past fifty years monographic studies have shown that this "geographical species concept" was ill-founded, and the true ranges of the species are now gradually becoming known. Macro-disjunct bryophyte species were discussed in recent papers by e.g. GROLLE (1969), SCHUSTER (1969, 1979), SCHOFIELD (1974), SCHOFIELD and CRUM (1972), VAN ZANTEN and PÓCS(1981) and FRAHM (1982), but all of these, except the latter two are concerned with temperate rather than tropical patterns. The reason

for the relative neglect of tropical disjuncts may be our still very incomplete knowledge of the taxonomy of tropical bryophytes and the deplorable state of the floristic inventory (see PRANCE 1977; GEISSLER and GREENE 1982). Nevertheless, it is evident that an increasingly large number of macro-disjunct species is emerging from recent literature dealing with tropical groups.

ARNELL (1958) was the first to give a tentative list of liverwort species common for both South America and South Africa. One of us (Pócs 1976a) has recently inventoried the macro-disjunct bryophyte species for tropical Africa and Asia and could list no less than 108 "palaeotropic" species (35 liverworts, 73 mosses), known to occur in each of the two continents but not elsewhere. In addition, five other categories of macro-disjunctions among the species from Africa were recognized: Cosmopolitan species (65), Temperate species (111), Pantropical species (55), Subantarctic species (111) and Neotropical species (66). It is with the latter category — to be qualified more correctly as "Afro-American" — that we are dealing with in this paper. For practical reasons, we shall confine ourselves to the Afro-American liverworts.

Relationships among the tropical African and American floras were recently reviewed for flowering plants by THORNE (1973), who found many parallels and resemblances among the Angiosperm genera of the two regions. KORNÁŠ (1981) gave a good account on the trans-oceanic disjunction between Africa and America and BORHIDI (1982) elucidated the special and ancient links between Caribbean and African floras.

For the bryophyte genera a comparison was made long ago by HERZOG (1926), who was able to demonstrate that bryofloristic similarities were greater among Africa and tropical America than among Africa and tropical Asia. While this would seem to indicate that a phyto-geographic subdivision into "Neotropic" and "Palaeotropic" is unjustified, HERZOG (1926) nevertheless maintained this subdivision because among tropical regions tropical America has the largest number of endemics. It would be tempting to reconsider this matter using up-to-date phytogeographic information on the tropical bryofloras. In any case, we would like to point out that a higher affinity at the generic level between Africa and America could be explained by the more complete Gondwanalandic connection between the two continents.

Biogeographers distinguish at least two major types of disjunction among species (cf. FRYXELL 1967): 1. bicentric taxa, in which the disjunct populations are not differentiated, and 2. vicarious taxa, where the disjunct populations are differentiated at the specific ("species pairs") or infraspecific level ("geographic races", or more properly called, subspecies) (cf. VAN STEENIS 1957, TOUW 1982). Although we are dealing primarily with the bicentric species, vicarious taxa whose status has been verified by monographic work (including some genera with bicontinental distribution) are taken into consideration as well as their ranges and mode of dispersal may offer further insight in the characteristics and possible causes of the Afro-American disjunctions. Furthermore, we have made a working list of African and American species said to be closely related but of unverified status. This list serves as a basis in our further search for Afro-American distributions (Table 3).

There are different approaches to explain intercontinental disjunctions among bryophytes. Some of them (ANDERSON 1963, FULFORD 1963, CRUM 1972, SCHUSTER 1969, 1979, Pócs 1976a, 1982a) underline the importance of geological events, especially of continental drift in the present distribution of bryophytes, which are (especially the Hepaticae) more conservative in their evolution, than phanerogams are. Others advocated the importance of long range dispersal: among southern temperate mosses VAN ZANTEN has shown correlations between the size of area of distribution and spore resistance and experimentally proved the survival ability of the spores of many species under conditions similar to those of high air currents (VAN ZANTEN 1976, 1978, 1979). Evidence opposing and supporting both views (and some others) is discussed at length by VAN ZANTEN and Pócs (1981). Some of their final conclusions (l.c. 544–547) are:

A) *Land connections* prior to the continental drift are very important for the understanding of evolution and migration of bryophytes. In the more conservative groups (primitive Hepaticae and much less mosses) actual species levels might have been established already before the split of great land masses. In other liverwort groups and most mosses, however, these ancient land connections are considered as explanatory for present-day relationships at family-, genus- and at vicariant species pair level.

B) *Step by step dispersal* following geological or climatic changes on the continents (or on islands and isolated land masses not too far from each other) causes modifications in the distribution of bryophytes, possibly followed by isolation and speciation.

C) *Long-range dispersal* by aerial transport of diaspores between continents or other land masses can drastically modify the picture achieved by plate tectonics and step by step dispersal. The effectiveness of long-range dispersal depends on the following conditions:

1. Spores or propagules must be produced in large quantities.
2. Diaspores must be small enough for aerial transport. (In general not larger than 25 μm in diameter.)
3. The diaspores must have resistance to desiccation and freezing.
4. The arriving diaspores need suitable habitats, and
5. competing ability with the autochthonous vegetation.
6. The receiving area has to be large and varied enough to provide successful migration chances, finally
7. should possess unsaturated niches, not filled by autochthonous vegetation.

Concluding from the above, successful long-range dispersal becomes likely when the species is bisexual, possesses gemmae, occurs on young oceanic islands or is weedy in character, living on bare, often secondary surfaces (VAN ZANTEN and PÓCS 1981). As VAN ZANTEN established (in VAN ZANTEN and PÓCS 1981: 523) diaspores of tropical bryophytes have much less resistance to desiccation and freezing than temperate ones, therefore chances for successful transoceanic dispersal should be smaller in tropical species, especially in those belonging to the lowland element.

Results

Taxa, for which Afro-American distribution has been established, are listed in Tables 1 (bicontinental species and vicarious taxa), 2 (genera) and 3 (presumed Afro-American species pairs of unverified status).

Among the earliest species proved to be disjunct Afro-American are *Radula flaccida* and *R. stenocalyx* (CASTLE 1939), others, such as *Schiffneriolejeunea polycarpa* (GRADSTEIN 1974), *Kurzia capillaris* and *Lepidozia cupressina* (PÓCS 1983) and *Lophocolea martiana* (this paper) were long hinted at to be Afro-American in earlier literature before they finally proved to be so. For more than half of the species listed in Table 1 Afro-American distribution was demonstrated within the last ten years, e.g. through the work of Dr. E. W. JONES, Dr. R. GROLE and others including the authors (GRADSTEIN 1974, 1980; BIZOT and PÓCS 1974; PÓCS 1977, 1983; VÁŇA 1980, 1982, VÁŇA et al. 1979). Many of them are the result of monographic comparisons between African and American taxa, but in some cases they resulted from new floristic discoveries, e.g. *Lejeunea autoica* (JONES 1979), *Gymnocoleopsis multiflora*, *Lophozia argentina* (VÁŇA 1982) or *Exormotheca pustulosa* (BISCHLER 1976). In other cases, e.g. *Herbertus subdentatus* (type from America), which was reported for Africa here for the first time, an African synonym has not yet been determined and remains to be detected among the various existing African binomina of the genus.

Not unexpectedly it turns out that for most of the Afro-American species type specimens originate from America, which should reflect the early date by which floristic explorations

Table 1

List of disjunct Afro-American liverwort species and vicarious taxa

Species or species pair	Altitudinal range*					Means of dispersal			Spore size if known, μm
	lowland	submontane	montane	subalpine	alpine	Gemmae or fragments	Spore autoic dioic		
<i>Ia. Tropical lowland element</i>									
1. <i>Acrolejeunea emergens</i>	+	+	—	—	—	+	+	—	45–60
2. <i>Aneura pseudopinguis</i>	+	+	+	—	—	—	—	+	13–16
3. <i>Cololejeunea cardiocarpa</i>	+	+	—	—	—	+	+	—	>40
4. <i>Lejeunea autoica</i>	+	(+)	—	—	—	—	+	—	>40
5. <i>Leucolejeunea uniloba</i>	+	+	—	—	—	—	+	—	23 × 40–50
6. <i>Lophocolea martiana</i>	+	—	—	—	—	—	+	—	?
7. <i>Mastigolejeunea auriculata</i>	+	—	—	—	—	—	+	—	>40
8. <i>Pycnolejeunea contigua</i>	+	+	—	—	—	—	+	—	>40
9. <i>Radula flaccida</i>	+	—	—	—	—	—	—	+	?
10. <i>Rectolejeunea brittoniae</i>	+	+	+	—	—	+	—	+	12–19 × <
11. <i>Schiffneriolejeunea polycarpa</i>	+	+	—	—	—	—	+	—	?
12. <i>Arachniopsis dissotricha</i> and <i>diplopoda</i>	+	—	—	—	—	—	?	—	
<i>Ib. Tropical montane element</i>									
15. <i>Aphanolejeunea exigua</i>	—	+	+	—	—	+	+	—	?
16. <i>Arachniopsis diacantha</i>	+	+	+	+	—	?	+	—	?
17. <i>Kurzia capillaris</i>	—	+	+	—	—	—	—	+	12
18. <i>Radula boryana</i>	—	+	+	—	—	—	—	+	?
19. <i>Radula stenocalyx</i>	—	+	+	—	—	+	—	+	?
20. <i>Symphyogyna brasiliensis</i>	—	+	+	—	—	—	—	+	24–28
21. <i>Syzygiella concreta</i>	—	+	+	—	—	—	—	+	?
22. <i>Diplasiolejeunea pellucida</i> and <i>albifolia</i>	+	+	+	—	—	+	—	+	20 × <
23. <i>Jungermannia amoena</i> and <i>borgenii</i>	—	+	+	—	—	—	—	+	18–22a 14–20b
24. <i>Leptoscyphus amphibolius</i> and <i>infuscatus</i>	—	—	+	+	—	—	—	+	13–15a
25. <i>Syzygiella manca</i> and <i>geminifolia</i>	—	—	+	+	—	—	—	+	24–32m

I Tropical alpine element

27. <i>Andrewsianthus jamesonii</i>	—	—	+	+	+	+	—	+	15-18
28. <i>Gymnocoleopsis multiflora</i>	—	—	—	—	+	—	+	—	?
29. <i>Herbertus subdentatus</i>	—	—	+	+	+	—	—	+	?
30. <i>Isotachis aubertii</i>	—	—	+	+	+	—	—	+	?
31. <i>Marsupella africana</i>	—	—	—	—	+	?	—	+	10-12
32. <i>Stephaniella paraphyllina</i>	—	—	—	—	+	?	?	?	?
33. <i>Colura ornithocephala</i> and <i>kilimanjarica</i>	—	—	—	+	—	—	—	+	?
34. <i>Gongylanthus liebmannianus</i> and <i>scariosus</i>	—	—	+l.	—	+s.	—	—	?	25-29s.
35. <i>Lethocolea glossophylla</i> and <i>congesta</i>	—	—	+	+	+	+	+c.	+g.	?

II. Subtropical-Mediterranean element

36. <i>Sphaerocarpos stipitatus</i>	+	—	—	—	—	—	—	+	tetrad 95-135 50-65
37. <i>Exormotheca pustulosa</i>	+	+	+	—	—	—	+	—	

IIIa. Southern temperate element penetrating into tropical mountains

38. <i>Clasmatocolea vermicularis</i>	+	+	+	—	—	—	—	+	16-20
39. <i>Heteroscyphus integrifolius</i>	?	?	+	—	—	—	+	—	?
40. <i>Hyalolepidozia bicuspidata</i>	+	+	—	—	—	?	—	+	12
41. <i>Lepicolea ochroleuca</i>	+	+	+	—	—	—	?	?	?
42. <i>Leptoscyphus expansus</i>	+	+	+	+	—	—	—	+	12
43. <i>Lophozia argentina</i>	—	?	?	+	—	—	—	+	?
44. <i>Schistochila alata</i>	+	+	+	—	—	—	—	+	17-23
45. <i>Tylimanthus limbatus</i>	+	+	+	—	—	—	—	+	?

IIIb. Wide southern temperate element penetrating up to Atlantic Europe

46. <i>Adelanthus decipiens</i>	—	+	+	—	—	—	—	+	12-16
47. <i>Adelanthus lindenbergianus</i>	+	+	+	+	—	+	—	+	12-16
48. <i>Colura calyptrifolia</i>	+	+	+	—	—	+	+	—	20-30 × 40-65
49. <i>Lepidozia cupressina</i>	+	+	+	+	—	—	—	+	10-16
50. <i>Leptoscyphus cuneifolius</i>	—	+	+	+	—	+	—	+	?
51. <i>Lejeunea</i> (<i>Microlejeunea</i>) <i>ulicina</i> complex	+	+	+	—	—	—	—	+	?
52. <i>Telaranea nematodes</i>	+	+	+	+	+	—	—	+	14-16

* Approximate ranges for altitudinal zones in the tropics are: lowland up to 800 m, submontane 800-1600 m, montane 1600-3000 m, subalpine 3000-3600 m, alpine above 3600 m. These values are valid in continental areas near the Equator, and much lower on oceanic islands and at higher latitudes.

started in South America and the inhospitality of the tropical African mainland to 18th and 19th century plant collectors. Where exist older African names, they are usually from the East African islands (e.g. *Acrolejeunea emergens*, *Isotachis aubertii*) or from the Cape (*Leptoscyphus expansus*, *Schistochila alata*).

Some of the Afro-American species discussed here may eventually turn out to be more widely distributed, especially where taxonomic studies are not yet world-wide. This is illustrated by the fact that among the bicentric Afro-Asiatic liverwort species listed recently by one of us (Pócs 1976), three have in the meantime proved to exist in tropical America as well and are thus in fact pantropical: *Anastrophyllum auritum* (VÁŇA 1982), *Iwatsukia jishibae* (VÁŇA 1980) and *Radula javanica* (YAMADA in litt.).

Although we would define Afro-American species in a strict sense as those restricted in their distribution to the African mainland and its surrounding islands as well as tropical and antipodal America, we would include here in this category as well those species with optimal occurrence in these regions but with occasional extensions into adjacent regions, e.g. Europe (Mediterranean and atlantic, Western Europe) or along the atlantic coast of North America and Ceylon. The latter island was considered to act as easternmost limit for the range of several Afro-American Lejeuneaceae by GRADSTEIN and INOUE (1980).

GROLLE (1969) discussed some examples of Afro-American distribution types among liverwort species and recognized two floristic elements:

a) Tropical element (*Arachniopsis diacantha*).

b) Subantarctic element (*Adelanthus lindenbergianus*, *A. decipiens* and *Stephaniella paraphyllina*). The latter species in our opinion does not belong here.

FRAHM (1982) reviewed the distribution of five Afro-American species of *Campylopus* and recognized three elements:

1. Southern temperate (subtropical) element,
2. Tropical-montane element,
3. Afroalpine-andine element.

While his first element seems to correlate with GROLLE's subantarctic element, and the other two with GROLLE's tropical element, his comparing the distribution of *Adelanthus lindenbergianus* and *A. decipiens* with that of the Afroalpine-andine element suggests, that the two classifications were not based entirely on the same principles.

A comparison of the maps and altitudinal distributions of the Afro-American liverworts discussed in this paper reveals the following geographical patterns (see also Table 1):

I. TROPICAL AFRO-AMERICAN

- a) Tropical lowland element (lowland-submontane)
- b) Tropical montane element (submontane-montane)
- c) Tropical alpine element (montane-alpine)

II. SUBTROPICAL-MEDITERRANEAN AFRO-AMERICAN

- a) Southern subtropical element
- b) Widely distributed element

III. TEMPERATE-SUBANTARCTIC AFRO-AMERICAN

- a) Southern temperate element
- b) Widely distributed element

I. TROPICAL AFRO-AMERICAN ELEMENTS

From Table 1, where the bicontinental tropical species and vicariants are listed according to their vertical, altitudinal distribution, the three main tropical elements become apparent. Division into altitudinal zones is according to

TROLL (1961) and regional literature (e.g. HEDBERG 1951, Pócs 1976b, CUATRECASAS 1954, CLEEF 1978). A few species of the above category could not be placed with certainty in one of the three elements. Their placement should remain tentative pending further study.

I.a. Tropical lowland element

1. *Acrolejeunea emergens* (Mitt.) Steph. (Lejeuneaceae) (Plate I/1)

Widespread in tropical Africa (lacking in S. Africa) from sea level up to 1500 m. In tropical America of more restricted occurrence and known only from few collections of mainland S. America and Central America (GRADSTEIN 1975). Recently the species was reported also from Ceylon, previously identified as *A. fertilis* (GRADSTEIN and INOUE 1980).

Acrolejeunea emergens is a rather xerotolerant species occurring as an epiphyte in mesic forests, deciduous savanna woodlands, often together with the Afro-American *Schiffneriolejeunea polycarpa* and *Mastigolejeunea auriculata* and with the pantropical *Frullania ericoides* (cf. also Pócs 1982b).

It is usually monoicous and produces spores as well as gemmae (caducous leaves) in great amount. GRADSTEIN (1975) suggested a West Gondwanic origin for *Acrolejeunea* subgenus *Acrolejeunea* (which includes *A. emergens*) and early tertiary migration towards its present area of distribution (tropical America including subtropical Central Florida, tropical Africa, Indo-China and Japan). Since *A. emergens* possesses copious means of dispersal, it seems unnecessary to postulate a Gondwanic origin for this species as an explanation of its present area of distribution.

2. *Aneura pseudopinguis* (Herz.) Pócs comb. nova (Aneuraceae) (Plate I/2)

Basionym: *Riccardia pseudopinguis* Herzog, Beih. Bot. Centralbl., Abt. B, 62; 560, Fig. 1a-b (1942).

Synonym: *Riccardia submarginata* S. Arnell, Bot. Not. 1953; 139.

Aneura pseudopinguis was not long ago described by HERZOG from Brazil. JONES in his account of African *Riccardia* (JONES 1956) does not mention other species of *Aneura*, as *A. pinguis*. ARNELL (1963; 86) was the first to recognize that some South African plants are identical with the American taxon. Later VANDEN BERCHEN (1972b) published it from tropical Africa. Pócs (unpublished material) has recorded it both from East and West Africa (Tanzania; Ukaguru Mts. and from the Ivory Coast). HERZOG (l.c.) gave very good description and figures of reproductive characters to distinguish this species from the related *Aneura pinguis*, namely the spores of *A. pseudopinguis* are of much smaller size and the atheridial branches are long and many paired. Although ARNELL gives vegetative characters too (ARNELL 1963; 86), based on the size of thallus cells, these characters seem to be in contradiction with his own account on Scandinavian *A. pinguis* (ARNELL 1956: 30). Therefore we regarded to be confirmed only the records of plants possessing either male branches or spores.

A. pseudopinguis is dioicous and in African samples usually only one sex is found in each locality. Vegetative reproduction is not known. In Africa it lives in humid lowland and montane forests, on muddy earth banks or on rotting wood, between altitudes of sea level and 1900 m. The type locality in Brasil seems to be somehow secondary ("Nähe des Stausees, Kraftwerk am Brachino"). If it is not a recent introduction into tropical America, records of the species can easily be hidden under neotropical *R. pinguis* records, as already HERZOG (l.c.) remarked. The South American *Aneura latissima* Spruce and *A. laurentiana* Steph. should also be checked for possible synonymy.

3. *Cololejeunea cardiocarpa* (Nees et Mont.) Schust. (Lejeuneaceae) (Plate I/3)

A species common in coastal tropical America (West Indies, Galapagos Is., etc.) but almost lacking in the inner Amazon basin (cf. SPRUCE 1884–85). In contrast, most African records are from inland, from Kenya to Zimbabwe. In the Cape ARNELL (1963; 174–176) recorded it under the name of *Leptocolea cristata* and *L. cristata* var. *lanciloba*; the description accompanied by pictures clearly refers to *C. cardiocarpa*. Additional records from Madagascar and New Caledonia (hence pantropical distribution) are confirmed recently by TIXIER (1979: 748). *C. cardiocarpa* is usually epiphyllous, but lives often among rather dry conditions not fit for most of the epiphyllous species. It has a wide ecological tolerance, occurring from lowland to lower montane forests up to 1500 m (in Zaire, on Mt. Kahuzi as high as 2300 m) under humid to subxeric conditions. In Cuba it is often the only epiphyllous species in semidry riverine forests. On the Galapagos Islands it is one of the most common liverworts (GRADSTEIN and WEBER 1982). As this liverwort flora is of recent origin and presumably has arisen via transoceanic air dispersal, the present distribution of *C. cardiocarpa* might best be explained by long-range migration. Moreover, the species is monoicous and produces copious spores as well as gemmae.

4. *Lejeunea autoica* Schust. (Lejeuneaceae) (Plate I/4)

A rare and remarkably disjunct species with localities in Florida (the type) and in tropical West Africa, where it was recently discovered by JONES (1979). According to Dr. JONES the West African populations are morphologically slightly different from the American ones, but "too closely allied . . . to justify separating them as a different species" (JONES 1979: 391).

Lejeunea autoica occurs in humid lowland or submontane forests (subtropical Florida at sea level, Ghana 730 m, Mt. Cameroun 1160 m) as a sciophilous epiphyte, rarely over rock, and tends to grow mixed among other (larger) bryophytes. Its tiny habit and likeness to other Lejeuneae, as well as our poor knowledge of this notoriously difficult, yet very common tropical genus, suggest that the actual distribution patterns of *L. autoica* is little more than a testimony of our incomplete understanding of the genus *Lejeunea*.

Lejeunea autoica is usually copiously fertile, yet mature sporophytes have not yet been recorded. Vegetative reproduction is unknown in this species.

5. *Leucolejeunea unciloba* (Lindenb.) Evans (Lejeuneaceae) (Plate I/5)

Widespread in tropical America, but known only from scattered localities — in the West Indies almost lacking — except in the coastal plain of southeast U.S.A. from where are many records (SCHUSTER 1980). In Africa *L. unciloba* is rare and thus far only known from South Africa (Cape, Natal) and from Tanzania, where it was recently collected by Dr. JONES (JONES 1973) in submontane rain forest and on roadside trees. In tropical America it is apparently a mesophytic to almost xerophytic species, occurring on smooth bark of trees and shrub as well as on rock. In Brazil it is found in Amazonian forests (leg. SPRUCE) as well as dry cerrado shrub. In Colombia the species was found not to be uncommon as a crown epiphyte in montane forests up to 2500 m (GRADSTEIN unpubl.) although there was only one previous record for the country. In Cuba it lives in semidry rock forests together with the monotypic *Microcycas calocoma* (GROLLE 1975). Apparently the species has been overlooked in the past as may be true for other crown epiphytes (e.g. *Pycnolejeunea contigua*). *L. unciloba* is autoicous and usually fertile, yet mature sporophytes are rarely recorded. Vegetative reproduction is unknown in the genus.

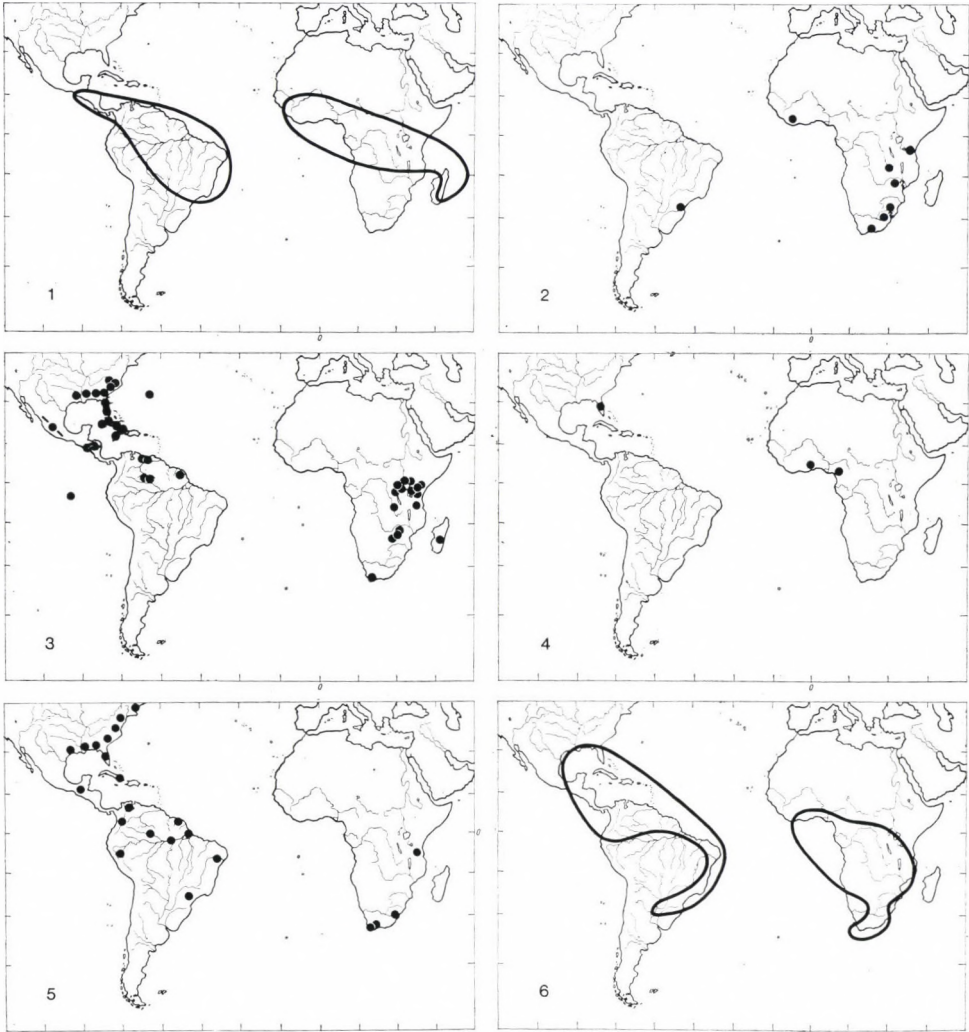


Plate I

Tropical lowland species. 1. *Acrolejeunea emergens* (Mitt.) Steph. (+Sri Lanka). 2. *Aneura pseudopinguis* (Herz.) Pócs. 3. *Cololejeunea cardiocarpa* (Nees et Mont.) Schust. (+N. Caledonia). 4. *Lejeunea autoica* Schust. 5. *Leucolejeunea uncioloba* (Lindenb.) Evans. 6. *Lophocolea martiana* Nees.

6. *Lophocolea martiana* Nees in G., L. et N., Syn. Hep. 152 (1845) (Geocalycaceae) (Plate I/6)

Syn. nov.: *Lophocolea congoana* Steph., Sp. Hep. 3: 170 (1907)

L. dusenii Steph., Sp. Hep. 3: 178 p.p. (1907)

L. newtonii Steph., Sp. Hep. 3: 170 (1907)

L. martiana is a very common species of rather mesic lowland forests of the West Indies, southeastern Brazil and also West Africa, where the species was known for a long time as *L. neutonii* or *L. congoana*. Their close relationships with *L. martiana* were noted by several authors (EVANS 1905, JONES 1953, SCHUSTER 1980) and JONES (l.c.) hesitated to recognize the African and American species as different but decided to maintain them because "the South American plants themselves appear to be in need of further study" (p. 191). A careful comparison by one of us (VÁŇA, msc.) in the course of a study of Cuban Lophocoleaceae revealed the published differences as non-existing.

L. martiana appears to be particularly common in Atlantic coastal regions but is more rare in lowland areas, at least in South America. In East and South Africa it also becomes more sporadic, occurring rarely and isolated in lowland forests. The species grows on rotten wood, or rarely on earth, in lowland and in submontane forests up to 1500 m altitude, rarely higher. It is monoicous and often fertile; gemmae are unknown.

7. *Mastigolejeunea auriculata* (Wils.) Schiffn. (Lejeuneaceae)

One of the commonest species of Lejeuneaceae in lowland tropical America and Africa with a rather wide ecological tolerance yet probably not very xerotolerant as it is absent from the Galapagos Islands (GRADSTEIN and WEBER 1982). In Africa the species was known as *M. carinata* (Mitt.) Steph. which was synonymized with *M. auriculata* by GRADSTEIN and INOUE (1980). The species also occurs on Ceylon and possibly elsewhere in Asia where a closely related and rather polymorphic species (*M. humilis*) occurs. Further revisionary work is needed to establish the actual distribution pattern of this species. *M. auriculata* is polyoicous (autoicous or dioicous) and may disperse by spores; gemmae are unknown in this genus.

8. *Pycnolejeunea contigua* (Nees) Grolle (Lejeuneaceae) (Plate II/7)

A tropical American species — with a confusing nomenclatural history (GROLLE 1979) — which was recently discovered in tropical Africa by JONES (1979). According to Dr. JONES the species grows in West Africa in humid lowland rain forests as a crown epiphyte of large canopy trees, and has therefore likely been overlooked in the past (JONES 1979). In Tanzania it grows on bark at 1650 m, in an open ericaceous heath, above waterfalls. It apparently lacks in the drier, deciduous forests. About its neotropical habitat little is known. It should be a lowland forest species there, not uncommon in the Amazon basin (fide SPRUCE). Dr. VITAL has found it on tree bases in São Paulo State. The species is autoicous, but mature sporophytes have not yet been recorded. Vegetative reproduction is yet unknown.

9. *Radula flaccida* Lindenb. et Gott. (Radulaceae) (Plate II/8)

Widespread in tropical Africa as well as in tropical America where it occurs from Florida (probably extinct there fide SCHUSTER 1980) southwards to Amazonia and also in the rainforest near Buenos Aires (leg. TONDUZ 1892, now probably extinct as well). The species is a common epiphyllous, occasionally corticolous element in humid tropical lowland rainforests, occurring at altitudes from sea level to 1000 m. It is dioicous but produces perianths (and spores?) frequently. In addition it has copious production of multicellular, leaf-born gemmae, which, considering their size should be effective means for short distance dispersal.

With *R. stenocalyx* (below) *R. flaccida* belongs to a pantropical group of about ten, chiefly epiphyllous species: *Radula* sect. *Epiphyllae* Castle ex Grolle (CASTLE 1968, YAMADA 1979). Except for the Afro-American *R. flaccida* and *R. stenocalyx* the species are supposedly confined to single continents, with 5 species occurring in Asia (all of them widespread). SCHUSTER recently (1980) regrouped these species and left only *R. flaccida* and the East African *R. pseudo-flaccida* in the sect. *Epiphyllae* Castle ex Grolle emend. Schust.

10. *Rectolejeunea brittoniae* Evans (Lejeuneaceae) (Plate II/9)

Since it was described from the Bahamas (EVANS 1911), the species became known also from the greater Antilles and from Florida (SCHUSTER 1980), where it seems to be quite widespread. Its African occurrence was hidden by the confusing synonymy clarified by JONES (1974), who gave a new name to the African plant: *Rectolejeunea arnellii* E. W. Jones recorded

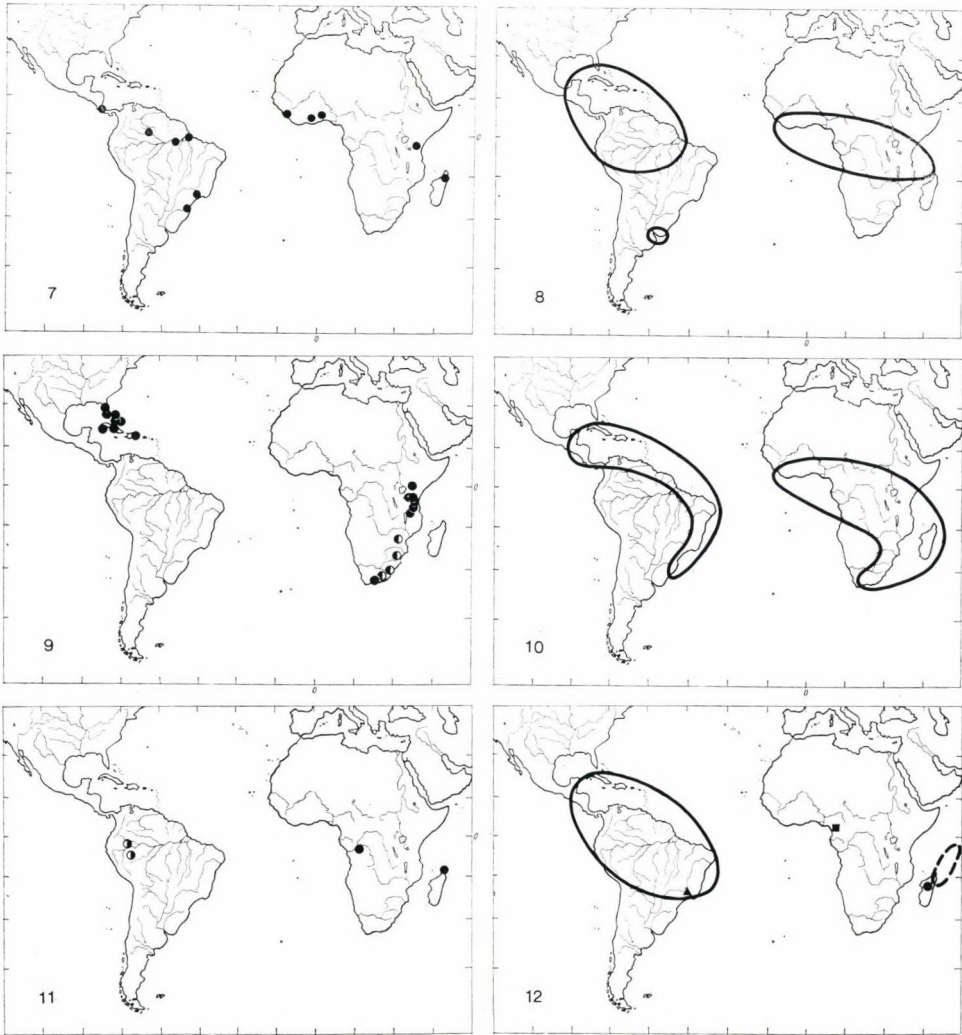


Plate II

Tropical lowland species. 7. *Pycnolejeunea contigua* (Nees) Grolle. 8. *Radula flaccida* (Lindenb.) Gott. 9. *Rectolejeunea brittoniae* Evans. (half dots: unconfirmed records). 10. *Schiffneriolejeunea polycarpa* (Nees) Gradst. (+ Sri Lanka, S. India). 11. *Arachniopsis dissotricha* Spruce (half dots) and *A. diplopoda* Pócs (full dots). 12. *Haplolejeunea* Grolle and *Symbiezidium* Trev. Full circle: *H. sticta* Grolle; square: *H. cucullata* (Steph.) Grolle; triangle: *H. spec.* Continuous line: *S. transversale* (Sw.) Trev. and *S. barbiflorum* (L. et G.) Trev.; broken line: *S. madagascariense* Steph.

from Tanzania and from the Cape, Knysna, from where it was published under the name of *Rectolejeunea rhodesiae* (Sim) S. Arnell by ARNELL (1963). Other SE African records remained unconfirmed. PÓCS (in OCHYRA and PÓCS 1983) recorded the species also from Mt. Kenya. SCHUSTER considers *Rectolejeunea brittoniae* and *R. arnellii* synonymous, thus the species is bicentric in distribution. It occurs near the sea level in Florida and on the Bahamas, becomes submontane on the greater Antilles, is again a lowland species in subtropical South Africa, while definitely montane in East Africa, occurring between 1500 and 3300 m (Mt. Kenya). *Rectolejeunea brittoniae* is in most cases corticolous or even ramicolous, living on tiny twigs. Only one case (Mt. Kenya) it was found on rotten logs. It generally occurs in deep shade of closed tropical forests, but can occur in more open vegetation types as well, when humidity is high.

R. brittoniae is dioicous and often produces perianths; mature sporophytes were observed only in America. The spores are relatively small, 12–19 μm in diameter. Vegetative reproduction is known by caducous leaf lobes, which leave long sections of the stem often naked. They develop on almost unmodified shoots. The fallen (and even the unfallen) lobes often produce new plantlets from their marginal cells. Although the peculiar bicentric distribution pattern is still difficult to explain, the freely developing caducous lobes seem to enhance long-range aerial dispersal for this species.

11. *Schiffneriolejeunea polycarpa* (Nees) Gradst. (Lejeuneaceae) (Plate II/10)

This species is widespread in tropical and South Africa, but in tropical America it seems to be largely restricted to coastal regions along the Atlantic Ocean and the West Indies. It grows as an epiphyte in rather mesic to subxeric evergreen forests, in cerradao shrub, in deciduous woodlands, orchards and on roadside trees, at altitudes from sea level up to 1500 m. Its distribution area was recently expanded with reports from Ceylon (GRADSTEIN and INOUE 1980) and Southern India (UDAR and AWASHTI 1982), but the Indian and part of the Ceylonese populations are from higher altitudes (1500–2200 m) and are morphologically slightly different (tubulose female bracteole, cf. UDAR and AWASHTI 1982, Fig. 1: 1, 20), indicating that a separate subspecies might be at hand. The specimens from lower altitudes on Ceylon, however, are fully identical to the Afro-American populations and represent the easternmost extension of the area of the species known thus far. Similar distribution patterns are known for *Acrolejeunea emergens* and *Mastigolejeunea auriculata*.

A closely related vicariant species, *S. pulopenangensis* (Gott.) Gradst., occurs in Indomalaysia.

S. polycarpa is autoicous and produces sporophytes freely. Vegetative reproduction is unknown. Its present distribution area resembles that of the cactus *Rhipsalis baccifera* (THORNE 1973, Fig. 1).

12. *Arachniopsis dissotricha* Spruce and *Arachniopsis diplopoda* Pócs (Lepidoziaceae) (Plate II/11)

The two *Arachniopsis* species form an interesting vicariant pair of related species within an isolated group of the genus. *A. dissotricha* is known since long from the upper Amazonian basin, both Brazil and Peru (SPRUCE 1882, 1885: 357, FULFORD 1968: 364). *A. diplopoda* became known by a collection made by G. CREMERS in northern Madagascar, from the herbarium of M. ONRAEDT, described, as a new species, by one of us (PÓCS 1984). An additional locality of the same species has been discovered from herbarium material (BR) collected by

Table 2
Liverwort genera largely restricted to America and Africa

Alt. range	Genus	Family	Total species	American species	African species	Species elsewhere
Trop. lowl.	<i>Arachniopsis</i>	Lepidoziac.	4	3	2	—
Trop. mont.	<i>Bryopteris</i>	Lejeuneac.	7	6	1	—
Trop. lowl.	<i>Haplolejeunea</i>	Lejeuneac.	2-3	1	2	—
Southern + tr. mont.	<i>Leptoscyphus</i>	Geocalycac.	24	19	6	2 Europe Azores
Trop. mont.	<i>Marchesinia</i>	Lejeuneac.	ca. 8	4 ?	3 ?	1 Europe
Trop. lowl.	<i>Odontolejeunea</i>	Lejeuneac.	ca. 5	4 ?	1-2	—
Trop. alp.	<i>Stephaniella</i>	Gymnomitriac.	5-6	5-6	1	—
Trop. lowl.	<i>Symbiezidium</i>	Lejeuneac.	3	2	1	—

C. J. MARTIAL-VOETS in Zaire (Mayumbé). It was found at both localities near sea level intermixed in the wefts of *Sprucella succida* covering the soil surface or litter on the ground of dense or semishaded equatorial forest. We do not have information about the ecology of the American species collected at both localities only by SPRUCE, but his statement suggests a similar habitat: "Ad fluvium Uaupés, in rivuli ripis umbrosis arborum radices investiens" (SPRUCE 1885: 357).

Arachniopsis dissotricha is dioicous, while *A. diplopoda* is known only in sterile state. Vegetative means of reproduction are unknown. These facts, together with the peculiar, very isolated and disjunct distribution of two related species seem to confirm their common Gondwanalandic origin and speciation since the Gondwana dissection. Their present distribution should thus be considered as of relict nature. The possibility of long-range air dispersal as an explanation for their distribution is almost to be excluded.

13. *Haplolejeunea* Grolle (Lejeuneaceae subfam. Tuyamaelloideae) (Plate II/12a)

The Afro-American genus *Haplolejeunea* was recently described by GROLLE (1975, 1979) and is comprised of two or three species: *H. sticta* Grolle from submontane Madagascar, *H. cucullata* (Steph.) Grolle from Cameroun and an unnamed species from São Paulo State, Brazil (close to *H. cucullata* and possibly identical). As each species is based on a single collection only, very little can be said about their distribution although they are apparently rare as they never turned up among the numerous African collections of Lejeuneaceae made by Dr. JONES and others (GROLLE 1979).

The species are autoicous but mature sporophytes have not yet been observed. Gemmae are known in other members of Tuyamaelloideae but not in *Haplolejeunea*.

Haplolejeunea is the only African and tropical American representative of this mainly tropical Asiatic (*Tuyamaella*) and eurysubantarctic (*Siphonolejeunea*, *Austrolejeunea*, *Nephrolejeunea*) subfamily. As *Haplolejeunea* was suggested to be the most primitive member of the subfamily its current distribution may be considered of relict nature similarly to the above *Arachniopsis* species.

14. *Symbiezidium* Trev. (Lejeuneaceae subfam. Ptychanthoideae) (Plate II/12b)

Known from tropical America by two common, widespread species, each with many synonyms: *S. barbiflorum* and *S. transversale* (VAN BEEK and GRADSTEIN, msc.). The old (18th century!) records of *S. transversale* from Hawaii [as *S. cryptocarpum* (Mitt.) Trev.] and from Tasmania [as *S. bacciferum* (Tayl.) Trev.] are unconfirmed, doubtful and probably based on erroneous labels (VAN BEEK and GRADSTEIN, msc.). A third species, *S. madagascariense* Steph., is known from Africa where it occurs on Madagascar (type) and the Seychelles (GROLLE 1978) but lacks on the mainland. The African and American species are very different, probably representing subgeneric groups, and thus indicating a long-time separation. The peculiar disjunction in *Symbiezidium* might better be explained by ancient continental movements following an early evolution in the eastern portion of Gondwanaland, rather than by long-distance dispersal, in which case its absence from mainland Africa would be very difficult to explain.

Symbiezidium does not stay alone with its peculiar distribution pattern. There are three moss genera following the same pattern: *Phyllogonium* and *Potamium* (RENAULD et CARDOT 1915: 8, HERZOG 1926: 215, JOVET-AST 1948: 46), finally *Adelothecium* (CROSBY 1976: 712). There are also unconfirmed records on the occurrence of the neotropical genus *Drepanophyllum* from Réunion Island (uncertain according to RENAULD 1897: 121).

The phenomenon, namely, that tropical American plants occur in Lemuria being absent in continental Africa, is well known among phanerogamic genera. Similar disjunctions have also been reported by MOORE (1973) for ceroxylid palms and by BORHIDI (1982: 237–239) for *Echinochlaena* (Poaceae, 6 American and 1 Lemurian species, none in continental Africa), *Oliganthes* (Asteraceae, 12 American and 9 Lemurian species, none in continental Africa), *Carpodiptera* (Tiliaceae, 5 + 1 species of the same pattern), *Oplonia* (Acanthaceae, 13 + 5 species), *Phenax* (Urticaceae, 25 + 3 species), *Rheedia* (Clusiaceae, 37 + 13 species), *Ravenala* (Musaceae, 1 American + 1 Madagascan species which occurs on Zanzibar Island too, but not in mainland Africa). These genera, called “peri-Afroamerican” element, are interpreted by STEARN (1971), as developed before the dissection of the Afro-American supercontinent and, at the time of the dissection, lacking in the interior of this enormous land mass, where drastic continental climate changes made them extinct. Therefore the formal central part of the supercontinent bears an impoverished flora and some coastal areas of the two continents are richer in these Gondwanalandic elements. BORHIDI (l.c.) provides much evidence in favour of STEARN’s theory based on his analysis on the Cuban phanerogamic flora. The same phenomenon is known in the distribution of some animals, e.g. reptiles.

In tropical America the species of *Symbiezidium* occur as epiphytes in moist tropical lowland and submontane forests, but they are lacking in more mesic areas. Thus, the genus is common on Cocos Island, where there is plenty of moist primary forest, but lacks entirely on the more mesic Galapagos islands (GRADSTEIN and WEBER 1982). The plants are autoicous and dispersal should be by spores.

I.b. Tropical montane element

15. *Aphanolejeunea exigua* Evans (Lejeuneaceae) (Plate III/13)

Many localities are known of this tiny epiphyllous species from the montane forests of the Caribbean region, with some extension southwards to Brazil and northwards to Cuba and Mexico. It became known from East Africa only recently (Pócs 1978: 693–694, without precise localities), where lives in the montane rain forests of the Ulugurus and Mt. Kilimanjaro. The

altitudinal range of the species in the more equatorial montane areas lies between 1000–3000 m, but descends much lower in islands, like in Cuba (400–1000 m, REYES ined.).

It is probably much more widespread in tropical Africa, first of all in the East African mountains, but due to its microscopic size escaped the attention of the non-hepaticologist collectors.

The species is monoicous and produces spori and gemmae as well.

16. *Arachniopsis diacantha* (Mont.) Howe (Lepidoziaceae) (Plate III/14)

Arachniopsis is a typical Afro-American genus and *Arachniopsis diacantha* is its most widely distributed representative, which covers the whole range of the genus, being distributed in East Africa from Rwanda to Cape in the West from Sierra Leone to Gabon, on Madagascar and the Mascarenes. In America is known from Cuba through the Venezuelan, Colombian and Peruvian Andes to the Amazonian basin, where it was known under the name of *A. coactilis*. Based on examination of the types and a wide selection of specimens, Pócs (1984) proved that *A. coactilis* does not differ specifically from *A. diacantha* and merits, at most varietal rank in which case its name should be *A. diacantha* var. *filifolia* (Spr.) Pócs. As there are many transitional forms within the whole range of distribution, the varieties are sympatric (see also GROLLE 1969: 578, Fig. 11/3).

The species occurs both in Africa and in America from almost sea level up to high altitudes, but it is commonest in wet submontane rain forests. In Venezuela *A. diacantha* goes up to 2000 m altitude, while in East Africa, on Mt. Kilimanjaro, it ascends as high as 2850 m in giant heather (*Erica arborea*) forest, almost reaching the forest line. It lives always on the shady, wet ground of rain forests, either on soil surface or more often on dead wood and litter, occasionally also on living bark or leaves. It seems to be strongly acidophilous, living together with other Lepidoziaceae (*Kurzia*, *Lepidozia*, *Bazzania*, *Telaranea* and in Africa also with *Sprucella*) species. *A. diacantha* is polyoicous, usually freely produces perianths although sporophytes are rare. Regeneration from leaf segment tip cells is described by FULFORD (1968: 362) and the detached, rhizoid bearing cells might serve as tools in vegetative reproduction.

17. *Kurzia capillaris* (Sw.) Grolle (Lepidoziaceae) (Plate III/15)

The widespread Afro-American *Kurzia capillaris* and its relatives were recently investigated by Pócs (1984). The African taxon was first treated as a variety of American *Lepidozia capillaris*, under the name of var. *sterilis* Gott., Lindenb. et Nees. Later it was distinguished from the American species by STEPHANI, as *Lepidozia tabularis* Steph. [= *Microlepidozia tabularis* (Steph.) S. Arn., *Kurzia tabularis* (Steph.) Grolle]. Large amounts of material studied from both continents proved that none of the differences given by STEPHANI are stable and the American *Kurzia capillaris* and the African *K. tabularis* are therefore considered identical (Pócs 1983).

Two other related taxa, *Lepidozia verrucosa* Steph. [= *Kurzia verrucosa* (Steph.) Grolle] and *Lepidozia stephanii* Ren. in Steph. [*Kurzia stephanii* (Ren.) Grolle] fall also within the range of variation of *Kurzia capillaris*. *K. stephanii* has leaf segments with their longest part consisting only one cell row and the segments in general are much smaller than those of the typical *K. capillaris*. In addition, it is restricted in its distribution to Madagascar, the Mascarenes and the old crystalline blocks of East Africa (Uluguru and Mulanje Mts.). Therefore its separation at subspecies level was proposed, as *K. capillaris* ssp. *stephanii* (Ren.) Pócs (l.c.).

Kurzia verrucosa differs from typical *K. capillaris* only in its stronger papillosity of the leaf cuticles. As the two taxa are sympatric in distribution, it merits only the rank of variety:

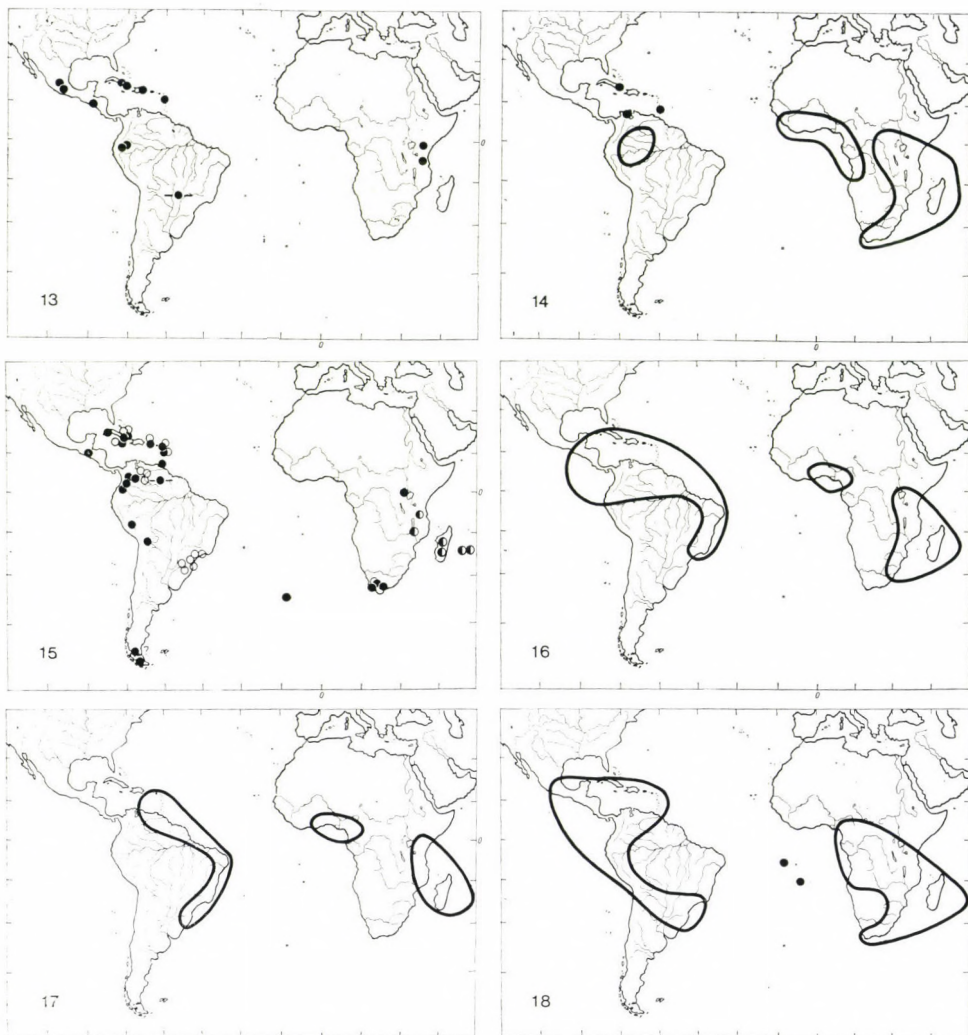


Plate III

Tropical montane species. 13. *Aphanolejeunea exigua* Evans. 14. *Arachniopsis diacantha* (Mont.) Howe. 15. *Kurzia capillaris* (Sw.) Grolle, full circle: var. *capillaris*; open circle: var. *verrucosa* (Steph.) Pócs; half circle: ssp. *stephanii* (Ren.) Pócs. 16. *Radula boryana* (Web.) Nees. 17. *Radula stenocalyx* Mont. 18. *Symphyogyna brasiliensis* Nees et Mont.

K. capillaris ssp. *capillaris* var. *verrucosa* (Steph.) Pócs l.c. There are transitions between *K. capillaris* and its ssp. *stephanii* and ssp. *capillaris* var. *verrucosa*.

Both varieties of *K. capillaris* ssp. *capillaris* are widespread in the montane forest belts of tropical America and Africa from Cuba to Tierra del Fuego and from Rwanda to Cape (more rare in Africa) and occur also on Tristan da Cunha. They descend also in submontane forests (near sea level in Cape) and on the other hand, occur near the forest line above 2000 m

as well. They prefer the acidic, peaty floor of more open forest types, like *Pinus maestrensis* wood in Cuba or elfin forests in Africa. They occupy also tree bases, rotting logs and sometimes acidic rock surfaces.

K. capillaris is dioicous, asexual means of propagation are not known.

18. *Radula boryana* (Web.) Nees (Radulaceae) (Plate III/16)

Known from scattered localities in tropical America and Africa, and thus far most frequently found in East Africa and the adjacent islands. *R. boryana* is a submontane species occurring chiefly between 1000–2000 m (at least in continental Africa -- on islands often at lower altitudes), hence almost lacking in the vast rain forest regions of the Amazon and the Congo belts. The species has also been recorded for tropical Asia (CASTLE 1936) but according to YAMADA (1979) Asiatic records belong to other species.

R. boryana grows on trees or rock, rarely on soil, in moist submontane forests. The species is dioicous and seldom fertile. As means of asexual reproduction are unknown in this species, it is not likely, that long-distance dispersal currently operates successfully in this species. The possibility, however, that dispersal mechanisms were better for this species in the past should not be ruled out. On the other hand, this might be a case where former land connections and subsequent migration and evolutionary retardation on the species level were responsible together for the present disjunct distribution pattern.

19. *Radula stenocalyx* Mont. (Radulaceae) (Plate III/17)

A submontane, but apparently tropical coastal Afro-American species occurring scattered along the Atlantic and Indian ocean. The species is usually epiphyllous but, at least in tropical Africa, frequently corticolous as well (more often so than *R. flaccida*). Its American localities are poorly documented (mostly 19th century) but it occurs in humid montane forests, at 1400–2100 m in mainland East Africa and at lower altitudes (down to 500 m) on the East African islands and in West Africa. "It is much more montane than *R. flaccida* but the two species overlap in their altitudinal range" (JONES 1979: 502–503).

R. stenocalyx is dioicous (as all species of the sect. *Epiphyllae*) but produces perianths (and spores?) frequently; in addition it has copious gemmae production, as in *R. flaccida*.

20. *Symphyogyna brasiliensis* Nees et Mont. (Pelliaceae) (Plate III/18)

GROLLE recently (1980) proved its identity with the African *S. lehmanniana* Mont. et Nees. Widely distributed in the tropical mountains of both continents between the altitudes of 1500–3000 m, while in subtropical Brazil and Cape, and on the Galapagos islands descends near to the sea level. Most African localities are from the southern portion of that continent.

The species is always terrestrial or rupicolous, occurring on wet ground, along trails, on streambanks, etc. In the Andes and in Southern Brazil the species is locally abundant. In the Andes and in Afroalpine localities occurs also in altimontane heath and in páramo vegetation even above the montane forest belt.

S. brasiliensis is dioicous and frequently fertile. Dispersal should be by spori as asexual means are as yet unknown. Its occurrence on young volcanic southern atlantic islands, as on Ascension and St. Helena as well as on the Galapagos islands indicates a capacity for long-range air dispersal.

21. *Syzygiella concreta* (Gott.) Spruce (Plagiochilaceae) (Plate IV/19)

Described by GOTTSCHÉ (1867) from Venezuela and Mexico; reported by INOUE (1966) also from SE Brazil (Caldas) and from Tristan da Cunha on the basis of type collections of *S. lingulata* Steph., and *S. tristaniana* S. Arnell, which were found to be conspecific with *S. concreta*. In Africa the species was recorded by VÁŇA et al. (1979) for Rwanda (mentioned also for Tanzania and Madagascar on the basis of unpublished records) and by BIZOT and PÓCS (1979) for Tanzania (Uluguru Mts.); it was collected also on Mt. Kenya. The African localities are all from montane altitudes (1900–2100 m), from the peaty ground of elfin forests and exceptionally, as epiphyllous (!). In Cuba it occurs on the bare lateritic soil of *Pinus maestrensis* forests at 1100 m altitude.

All species of *Syzygiella* are dioicous (INOUE 1966). In *S. concreta* perianths are known, but the sporophyte is as yet undescribed. Gemmae are also unknown. The record of this species from Tristan da Cunha, an oceanic island group of relatively recent origin (maximum 25 million years old) and located several thousands of miles from the mainland between S. Africa and S. America, may indicate that transoceanic air dispersal is operative in this species (cf. FRAHM 1982). According to pteridological evidence (MANTON and VIDA 1968, TRYON 1966) immigrants "have come mainly though not entirely from the general direction of South America" by long range air dispersal, then in the case of ferns, speciation took place mainly by polyploidization.

22. *Diplasiolejeunea pellucida* (Meissn.) Schiffn. and *Diplasiolejeunea albifolia* (Tayl.) E. W. Jones (Lejeuneaceae) (Plate IV/20)

Closely allied vicariant species pair sometimes treated as conspecific, although they are distinct, having constant differences in the length and shape of their lobule teeth.

D. pellucida occurs from the lowland to the montane forest belt of the Caribbean region and northern South America, between 200 and 1750 m altitudes, while *D. albifolia* seems to be more montane, occurring except for its type locality in the lowland forest belt of Nigeria between 1370 and 2100 m in the montane forests of East Africa, where it was first collected by PÓCS (BIZOT and PÓCS 1974: 410). From Mauritius it is mentioned already by EVANS (1912: 214) under *D. pellucida* based on the old collection made by RODRIGUEZ.

Both species are obligate epiphyllous in rain forests, dioicous, with discoid gemmae common on the leaf surface. *D. pellucida* shows variability in the occurrence of a malleiform apical lobule tooth, while *D. albifolia* in East Africa has a variety with a several cells broad hyaline margin.

23. *Jungermannia amoena* Lindenb. et Gott. and *Jungermannia borgenii* Gott. (Jungermanniaceae) (Plate IV/21)

J. amoena is a montane species occurring at many localities in south-eastern Brazil and having scattered localities also in the Peruvian and Colombian Andes and one-one localities in Mexico and Jamaica. The species grows on soil at higher elevations (800–2500 m, VÁŇA 1974). The African vicariant, *J. borgenii*, is the commonest African *Jungermannia*, recorded from Nigeria, Cameroon, and from Uganda and Kenya to South Africa, incl. Madagascar and the Mascarenes. It grows on places ecologically similar to the above, on soil and on bare, often on wet rocks, at more or less open places between 1000 and 3300 m (Mt. Elgon), seldom at 400 m (Rep. Congo).

Both species are dioicous and produce spores in most cases.

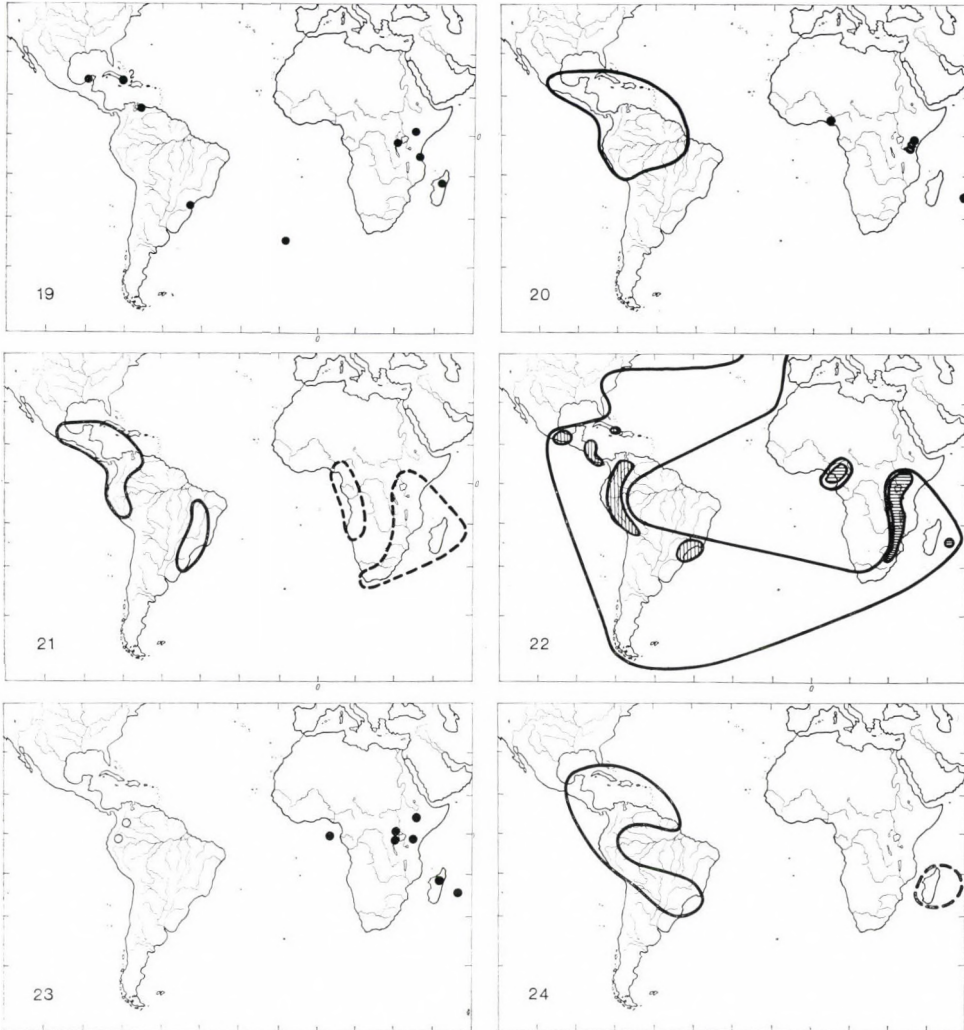


Plate IV

Tropical montane species. 19. *Syzygiella concreta* (Gott.) Spruce. 20. *Diplasiolejeunea pellucida* (Meissn.) Schiffn. (line) and *Diplasiolejeunea albifolia* (Tayl.) E. W. Jones (dots). 21. *Jungermannia amoena* Lindenb. et Gott. (continuous line) and *Jungermannia borgenii* Gott. (broken line). 22. *Leptosecyphus amphibolius* (vertically) and *L. infuscatus* (horizontally striped areas). The continuous, solid line marks the area of the genus *Leptosecyphus* Mitt. (total distribution of 24 species). 23. *Syzygiella manca* (Mont.) Steph. (open) and *S. geminifolia* (Mitt.) Steph. (full circles). 24. *Bryopteris* Nees. Continuous line: 6 neotropic species, broken line: *B. gaudichaudii* Gott.

24. *Leptoscyphus amphibolius* (Nees) Grolle and *Leptoscyphus infuscatus* (Mitt.) Jones (Geocalycaceae, (Plate IV/22)

These two vicariant species form the section *Physoscyphus* (GROLLE 1962: 51).

L. amphibolius represents a relatively common species growing on rotten logs, rarely on sandy soil in the mountain forests of the Andes from the southern part of Mexico to Bolivia; it is known also from the Sierra Maestra in Cuba and from mountains of south-eastern Brazil. The species was collected at elevations 1000-3000 m (GROLLE 1962, FULFORD 1976, VÁŇA ined.).

The African vicariant, *L. infuscatus*, is known from the montane rain forests of Fernando Poo and Mt. Cameroon in West Africa and has several localities in East Africa in Ethiopia, Zaire, Mt. Muhawura, Mt. Ninagongo, Mt. Kilimanjaro, Ruwenzori Mts., Malawi and in the Inyanga Mts. in Zimbabwe; also on Réunion island (GROLLE 1962, BIZOT and PÓCS 1974). Questionable is a locality in Java, based on the data of the label of a *Leptoscyphus motleyi* Mitt. specimen (conspecific with *L. infuscatus*), where a probably label change is at hand. No other collection of any *Leptoscyphus* is known from Asia (cf. also GROLLE 1962).

Both species are dioicous and produce sporophytes. Gemmae are unknown.

25. *Syzygiella manca* (Mont.) Steph. and *Syzygiella geminifolia* (Mitt.) Steph. (Plagiochilaceae) (Plate IV/23)

S. manca is an Andean species known from the northern part of South America (Ecuador, Colombia — cf. INOUE 1966), while its African vicariant, *S. geminifolia*, was treated by INOUE (l.c.) as two species (*S. geminifolia* and *S. ruwenzorensis* Steph.). This concept was criticized by JONES (1976) and the two species were shown to be identical by VÁŇA et al. (1979). Recently, *S. geminifolia* has become known from scattered localities in S. Tomé, Ethiopia, Ruwenzori, Rwanda, Mt. Kilimanjaro, Madagascar and Réunion (VÁŇA, in prep.). The report of *S. geminifolia* from Brazil (INOUE 1966) is erroneous; the material belongs to the broad-leaved form of *S. perfoliata* or *S. concinna*.

S. manca grows on rocks in the montane belt (about 2000–2500 m), while *S. geminifolia* is known from trees and rocks in montane rain forests at 1650–2000 m (reaching 3300 m in Ruwenzori Mts.).

Both vicariants are dioicous and known with one exception only in sterile conditions (STEPHANI 1902, described sporophyte of *S. manca*). Gemmae are unknown.

26. *Bryopteris* Nees (Lejeuneaceae subfam. Bryopteridioideae) (Plate IV/24)

A clearly defined genus representing a monotypic subfamily, with 6 species in tropical America (*B. diffusa*, *B. filicina*, *B. flaccida*, *B. fruticulosa*, *B. liebmannaiana* and *B. trinitensis*) and a 7th species on Madagascar: *B. gaudichaudii* (STOTLER and CRANDALL-STOTLER 1974). In addition, the neotropical *B. trinitensis* has been reported from several scattered palaeotropical localities, but all these are very old and poorly documented and therefore for the moment can hardly be accepted (STOTLER and CRANDALL-STOTLER, l.c.). The alleged Nepal record of *B. trinitensis* (STOTLER and CRANDALL-STOTLER l.c.) was recently shown, by MIZUTANI (1979), to represent misidentified *Ptychanthus striatus*.

If the occurrence of *Bryopteris* in Madagascar is correct (there are only a few 19th century records for *B. gaudichaudii*, notwithstanding active collecting on Madagascar during recent years by ONRAEDT, TIXIER a.o.), then the distribution of *Bryopteris* may be compared with that of *Symbiezidium* and other “peri-Afroamerican” elements, indicating a Gondwanic

origin for the genus. Potential habitats should be plentiful for *Bryopteris* on the African mainland! Even on the old crystalline blocks of Eastern Tanzania, where floristic affinities to Madagascar are close (Pócs 1974), neither *Bryopteris*, nor *Symbiezidium* have been found.

The Madagascan *B. gaudichaudii* is apparently a close relative and vicariant of the common neotropical *B. diffusa*; morphologically these two species seem clearly separated from the rest of the genus and probably represent a proper section, with its own evolutionary history.

In tropical America the genus is very common, representing epiphytes in mesic to moist submontane forests, both primary and degraded. *Bryopteris* disperses there by spores, and vegetatively probably by flagelliform branches. Its species are either autoicous or dioicous.

I.c. Tropical alpine element

27. *Andrewsianthus jamesonii* (Mont.) Váňa, **comb. nova** (Jungermanniaceae) (Plate V/25)

Basionym: *Jungermannia jamesonii* Mont., Sylloge Gen. Spec. Crypt., p. 60 (1856).

Lectotype: Ecuador, "Quito, M. JAMESON, cum *Calypogeia trichomanis*"; PC-Mont. !; isotype: PC-Mont. !

Syn. nov.: *Jungermannia achroa* Spruce, Trans. Proc. Bot. Soc. Edinburgh 15: 514 (1885). Holotype: Ecuador, Andes Quitenses, Mt. Tunguragua, 2200 m, R. SPRUCE: MANCH (not seen); isotype: G !

Cephalozopsis achroa (Spruce) Schiffn. in Engler, Prantl, Nat. Pflanzenfam. 1 (3): 85 (1893)

Sphenolobus achrous (Spruce) Steph., Spec. Hep. 2: 174 (1902)

Andrewsianthus achrous (Spruce) Schust., Nova Hedwigia 8: 207 (1964)

Lophozia kilimanjarica S. Arnell, Ark. Bot. 3 (16): 539 (1956). Holotype: Tanzania, Mt. Kilimanjaro, O. HEDBERG 1363d; UPS !

Andrewsianthus kilimanjaricus (S. Arnell) Grolle et Váňa, J. Hattori Bot. Lab. 48: 228 (1980)

Jungermannia jamesonii Mont. (type from Ecuador) is probably the earliest name for *A. kilimanjaricus*, which was treated in detail by VÁŇA (1980), who demonstrated the Afro-American distribution of the species. The lectotype and isotype specimens in PC-Mont. (probably the only available type material) consist only of some stems without branching, but the other characteristics (leaf form, cell size and form etc.) exclude *Lophozia incisa* (Schrad.) Dum., which also occurs in the same area and was mostly confused with *A. jamesonii*.

Jungermannia achroa (= *A. achrous*) was known only from type collection, the holotype of which was not obtainable from MANCH (missing?). The only isotype material available (G, STEPHANI herbarium) consists of a few poorly developed male stems with strongly unequal leaf lobes and reduced leaf margin dentation (male bracts!); the description of such plants gave a basis for the distinguishing characteristics of this species cited in SCHUSTER (1964, 1966).

SCHUSTER (1978) described *Lophozia incisa* ssp. *austrigena* Schust. from Venezuela. The type material is not available, but this taxon is probably also conspecific with the present species.

The known distribution of *A. jamesonii* was published by VÁŇA (1980); recently many new localities were added from Ecuador (Carchi, GRADSTEIN et al. 3427 and the two above-mentioned type specimens), Colombia (new localities from Cundinamarca, Boyacá, Meta, Tolima) and Mexico (Oaxaca, Sierra Juárez, A. J. and E. SHARP 9895-a). *A. jamesonii* is

restricted both in East Africa and in the Andes to high-montane and alpine localities, between 2000 and 4000 m, but extending up to 4750 m on summit rocks of Mt. Pichincha near Quito, Ecuador. The species is terrestrial or saxicolous and sometimes grows together with *Lophozia incisa*, which it resembles. The habitat is montane mossy forest, Ericaceous heath, subpáramo or páramo vegetation.

It is dioicous but frequently fertile. Within *Andreusianthus* (pantropical-circum-subantarectic genus of ca. 20 species) *A. jamesonii* has probably the best capacity for dispersal as it is the only species which develops gemmae besides spores. This may possibly explain why *A. jamesonii* is the only macro-disjunct species within the genus.

28. *Gymnocoleopsis multiflora* (Steph.) Schust. (Jungermanniaceae) (Plate V/26)

An apparently rare, tropic-alpine species known from the Andes (Bolivia, Peru, Colombia — unpublished records from Sierra Nevada del Cocuy and Risaralda —, and Venezuela) and in Africa from Zaire (VÁŇA 1982). Its altitudinal range extends from 3500 m (Zaire: Karisimbi) to 4400 m (Bolivia, near Tunarisea). It grows on humid, boggy ground among higher plants and on moist rocks.

SCHUSTER (1966) separated *Gymnocoleopsis* [as a monotypic genus, the position of *G. cylindriciformis* (Mitt.) Schust. from Kerguelen is not clarified] from *Gymnocolea* on the basis of the persistent perianths (caducous in *Gymnocolea*), and described the sporophyte. *G. multiflora* is autoicous but often sterile. Nevertheless, dispersal by spores should be possible.

29. *Herbertus subdentatus* (Steph.) Fulf. (Herbertaceae) (Plate V/27) (data kindly provided by G.B. A VAN REENEN, Utrecht)

H. subdentatus is known in tropical America between 3100 and 4350 m in the montane and alpine zones of the Andes, from Mexico to Bolivia, and from the summit of Mt. Roraima (FULFORD 1963, VAN REENEN 1982). It is a very variable species (VAN REENEN 1982) but there are sufficient morphological traits to separate it from other tropical American species, such as the numerous ventral intercalary flagelliform branches, the imbricate and appressed, secund leaves, the broadly V-shaped leaf sinus and the convex vitta which is especially notable in the underleaves. The species is mainly restricted to regions with heavy precipitation (e.g. above 3000 mm in Tanzania) and high atmospheric humidity.

The same habitat and morphological characters apply to a number of *Herbertus* specimens recently examined by the above author from Africa and identified as *H. subdentatus*. These specimens are from the collections made by T. Pócs on Mt. Kilimanjaro and the Southern Highlands of Tanzania, between 1700–3300 m. Strikingly, about half of the collections contain sporophytes while these are seldomly encountered in tropical American populations. Following GROLLE (1978), the African material of *H. subdentatus* belongs in the “*H. capensis* complex”, but the name *Herbertus subdentatus* can be used safely here since all the names of species assigned to this complex by GROLLE (1978) are of younger date.

A preliminary comparison of *H. subdentatus* with species from other regions revealed a rather close relationship to the holarctic *H. aduncus* (which, however, remains distinct on the species level, cf. VAN REENEN 1982), and a very close similarity to the atlantic European *H. borealis* Crundw. Based on examination of the type (GL), kindly provided by Dr. CRUNDWELL, it appears that the only morphological difference between *H. subdentatus* and *H. borealis* is in the position of the leaves, which are more spreading in *H. borealis*. According to MILLER (cited by CRUNDWELL 1970) *H. borealis* is very near to the Asiatic *H. himalayana* (Steph.) Chopra. These further relationships might have considerable taxonomic and phytogeographical

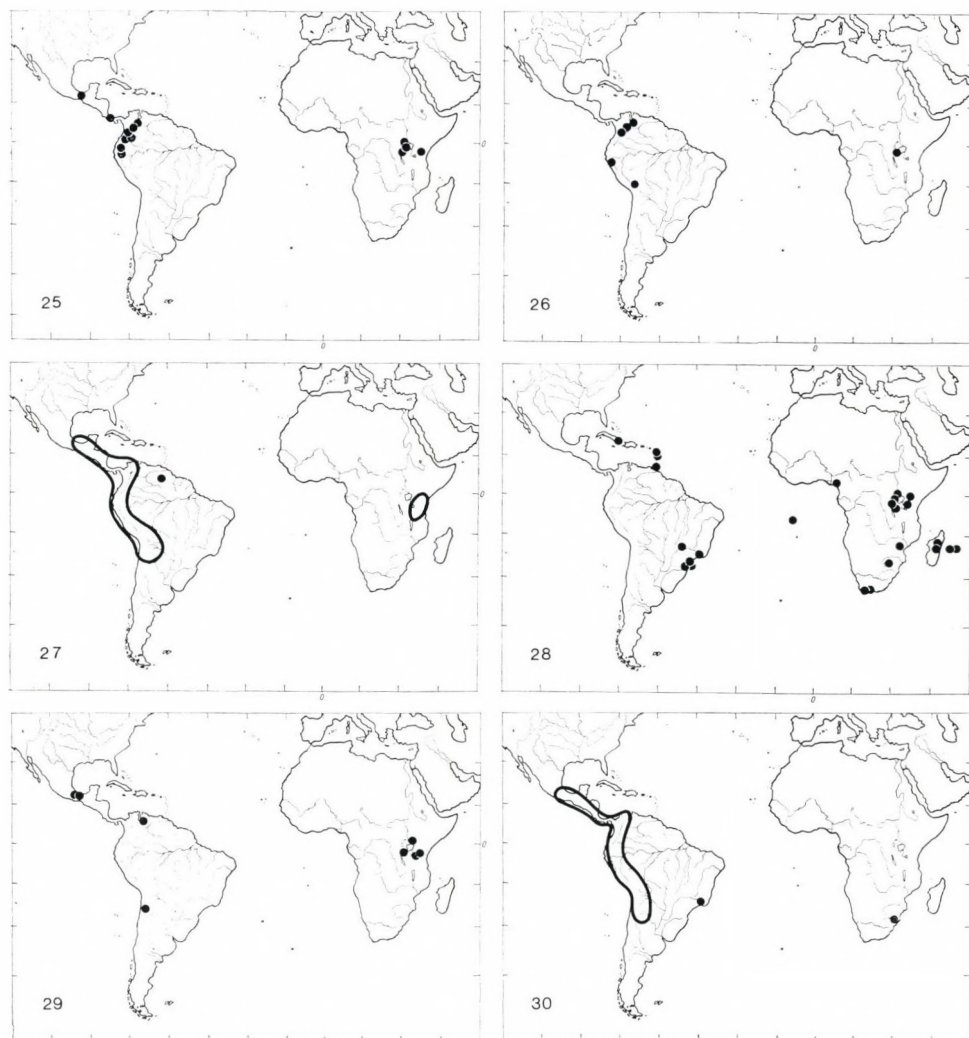


Plate V

Tropical alpine species. 25 *Andrewsianthus jamesonii* (Mont.) Váša. 26. *Gymnocoleopsis multiflora* (Steph.) Schust. 27. *Herbertus subdentatus* (Steph.) Fulf. 28. *Isotachis aubertii* (Schwaegr.) Mitt. 29. *Marsupella africana* Steph. ex Bonner. 30. *Stephaniella paraphyllina* Jack.

implications. Yet, it is too early to draw conclusions based on these preliminary observations and therefore it seems better to treat *H. borealis* as a separate species pending further study.

30. *Isotachis aubertii* (Schwaegr.) Mitt. (Isotachidaceae) (Plate V/28)

VÁŠA (1982) showed that *I. aubertii* is a common, montane to tropic-alpine species in Africa where it occurs at 2000–4500 m in the East African mountains and on Mt. Cameroon,

at 1500–2000 m in South Africa and at lower altitudes on the islands (on Réunion even at 400 m!). The species is rather polymorphic like other species of this genus and has many African synonyms.

In tropical America the species was reported by HATCHER (1961) from two areas: montane SE Brazil (Itatiaia) and scattered localities in the West Indies reaching to Sierra Maestra in Cuba. As HATCHER's monograph of *Isotachis* (HATCHER 1961) proved unsatisfactory at least for Africa (VÁŇA 1982) it remains to be proved whether the absence of *I. aubertii* from the main mountain ranges of tropical America is correct. The careful study of many collections from the South American Andes (VÁŇA, GRADSTEIN) agree with HATCHER's (1961) results; no specimen of *I. aubertii* from the Andes was found.

All species of *Isotachis* are dioicous but sporophytes may be found under favourable (wet) conditions. The occurrence of *I. aubertii* on the young volcanic, oceanic island of Ascension in the middle of Atlantic Ocean between Africa and America indicates the possibility of recent long-range dispersal for this species.

31. *Marsupella africana* Steph. ex Bonner (Gymnomitriaceae) (Plate V/29)

Syn. nov. *Acolea africana* Steph., Spec. Hep. 6: 77 (1917). Lectotype sensu GROLLE in sched.

1963: Kilimanjaro, C. UHLIG s.n., G-10874!, islectotype S!

Gymnomitron africanum (Steph.) Horik., Acta Phytotax. Geobot. 13: 212 (1943)

Marsupella chilensis Steph. ex Bonner, Candollea 14: 254 (1953). Holotype: Chile, GAY s.n., G-10880!, isotype PC

Marsupella hedbergii S. Arnell, Ark. Bot. 3 (16): 544 (1956). Holotype: Tanzania, Mt. Meru 3400 m, O. HEDBERG 2369b, UPS!, isotype S!

Marsupella subquadrata Steph. in sched. et Icones ined. Type: Kilimanjaro, Garanga Bach, 1901 C. UHLIG, G-15048!

A tropical alpine species which was known from the high mountains of East Africa (Mt. Kilimanjaro, Mt. Meru, Mt. Karisimbi and Mt. Elgon). In the meantime it has become known from the American Cordilleras as well (Mexico: Mt. Popocatepetl, Mt. Nevado de Toluca, Mt. Ixtaccihuatl; Venezuela: Merida; Chile).

In Africa the species occurs in rather xerophytic alpine and subalpine vegetation types, in rock crevices usually in the *Philippia* zone but on Mt. Kilimanjaro in the alpine tussock and *Helichrysium* semidesert zones (3600–4500 m). In tropical America it grows in alpine grassland on mesic basalt outcrops; in Mexico even on active volcanoes.

The species is dioicous and usually sterile. The dispersal via stem fragmentation (as is postulated for *Stephaniella* occurring among similar dry-alpine environmental conditions) is problematic, but should be possible.

32. *Stephaniella paraphyllina* Jack (Gymnomitriaceae) (Plate V/30)

A tropical alpine species distributed all along the Andes from northern Argentina to Colombia and known also from Costa Rica and Mexico, ranging in altitude from ca. 3000–4500 m. In addition, there is a single record from Africa: Natal, Drakensbergen, 3300 m. GROLLE (1969), who mapped the species, considered its distribution as showing a "subantarktische Beziehung". Since the species occurs only in tropical and southern subtropical regions, and is very common in the northern Andes (páramo region), this qualification is less suitable. We would rather qualify it as a tropical alpine species and would predict it to turn up once at the high levels of the East African mountains as well.

The genus, as a whole, is alpine Afro-American with 5–6 species in the Andes (SCHMITT and WINKLER 1969). *S. paraphyllina* is far the most common species among them and also the only species known from Africa. All species are strongly specialized xeromorphic, adapted to open soils in the alpine environment exposed to extreme climatic conditions (radiation, desiccation, frost).

The species is autoicous or dioicous, but apparently sporophytes are rare. Asexual means of dispersal in *Stephaniella* remain unknown, but we would assume that stem fragments of the worm-like plants could be carried away by winds when the open soils on which they grow dry out entirely.

33. *Colura ornithocephala* Herz. and *Colura kilimanjarica* Pócs et S. J.-Ast (Lejeuneaceae) (Plate VI/31)

A vicariant species pair belonging to the very conservative Section *Oidocorys*. All members of this group are distributed in the dissected parts of former Gondwanaland. Their taxonomy, phytogeographical relations were discussed in details by JOVET-AST (1980), who is in the opinion, that the distribution of these closely related species or their ancestor could happen to a long distance before the continental drift, nearly 100 million years ago. Since that time very little speciation took place. Anyway, the occurrence of the African species on a young tertiary volcano indicates that *C. kilimanjarica* had to survive at an other place and that this locality is the result of more recent migration. Both species are tropical subalpine, living in subpáramo-like vegetation at 2900–3800 m altitude, and are still known from very few collections only [*C. kilimanjarica*: only type collection; *C. ornithocephala*: Ecuador (type) and Colombia, Risaralda (leg. AGUIRRE et GRADSTEIN)]. There is a doubtful record of *C. ornithocephala* from the Galapagos islands as well (BARTRAM and ARNELL 1961).

C. ornithocephala seems to be dioicous, while *C. kilimanjarica* is monoicous. Asexual way of reproduction was not observed.

34. *Gongylanthus liebmannianus* (Lindenb. et Gott.) Steph. and *G. scariosus* (Lehm.) Steph. (Arnellaceae) (Plate VI/32)

A vicariant species pair of Afro-American montane-alpine, terrestrial liverworts. *G. liebmannianus* lives in the high mountain areas of tropical America, ranging from ca. 3200 up to 4300 m (Mexico, Central America and the Andes). Occasionally is found at lower elevation, in the upper forest zone, on roadsides (e.g. Itatiaya in SE Brazil). In Colombia it is mainly a páramo species (GRADSTEIN et al. 1977: 397) extending up to the superpáramo in the Sierra Nevada del Cocuy. It grows often associated with *Stephaniella paraphyllina*, but *G. liebmannianus* prefers more shadow and humidity than *Stephaniella*. It is found sometimes even in Sphagnum bogs. One locality is known from the humid, upper Andean *Weinmannia* cloud forest.

The related *G. scariosus* is known only in subtropical South Africa, from the Cape peninsula and from the 1623 m high Anysberg near Ladysmith (ARNELL 1963). We do not know much about its ecology.

Probably both species are dioicous. The marsupium of *G. liebmannianus* is 3 mm, while that of *G. scariosus* is only 1.5 mm long (fide descr. STEPHANI 1906 and S. ARNELL 1963). ARNELL (l.c.) observed the sporophytes and spores of *G. scariosus* as well. According to him its spores are large, collapsing when dry (25–29 μ m in diam.) and “evidently dispersed by wind”. Sporophytes of the American plant are not known.

35. *Lethocolea glossophylla* (Spruce) Grolle and *Lethocolea congesta* (Lehm.) S. Arnell (Acrobolbaceae) (Plate VI/33)

Lethocolea glossophylla is a high-Andean species, occurring sporadically in Colombia, Ecuador, Peru (? and Bolivia). *Lethocolea congesta* (Lehm.) S. Arnell is known from the high mountains of East Africa (Mt. Elgon, Ruwenzori Mts., Mt. Muhawura, Mt. Bysoke, Mt. Meru, Kilimanjaro Mts. and Rungwe Mts.), from South Africa (Transvaal, Natal, Cape), from the islands of Réunion, Inaccessible and Tristan da Cunha.

The ecology of the two species seems rather similar. *Lethocolea glossophylla* occurs mostly on steep, shaded, moist earth and rocks in the upper montane to alpine zone (2700–3750 m in Colombia according to GRADSTEIN and HEKKING 1979: 119), while *L. congesta* is known from montane forest and subpáramo-like vegetation, as subalpine *Philippia* moorland on earth and on wet rocks near watercourses, between 2250 and 3800 m according to ARNELL (1956), BIZOT and PÓCS (1974, 1979). It occurs much lower in South Africa, on Réunion (1800 m fide ARNELL) and at 80–1200 m on Tristan da Cunha (ARNELL 1958).

L. glossophylla is dioicous, while *L. congesta* probably paroicous. The sporophyte is known only in *L. glossophylla*. Main type of dispersal in both species is by disciform gemmae. The occurrence of the African species on Tristan da Cunha seems to prove its long range air dispersal ability from East to West. However, the taxonomic relationship of this species pair needs further study.

II. SUBTROPICAL-MEDITERRANEAN AFRO-AMERICAN ELEMENTS

Altogether only two species belong here, which cannot be classified elsewhere; even the two represent different types of distribution:

II.a. Southern subtropical element

36. *Sphaerocarpos stipitatus* Bisch. ex Lindenb. (Sphaerocarpaceae) (Plate VI/34)

With *S. mucilloi* Vianna from Southern Brazil *Sphaerocarpos stipitatus* is the only representative of the genus known with certainty from the southern hemisphere (there are uncertain records of *S. texanus* as well). The genus is a characteristic element of dry subtropical-mediterranean regions and the distribution of *S. stipitatus* seems to fit that pattern very well. There are only three localities known thus far (PROSKAUER 1954, ARNELL 1963): Chile, Valparaiso, leg. BERTEN 1829 (not rediscovered since in America!) and two more recent localities in S. Africa, where it was found on muddy, temporarily moist riverbanks. More intensive collecting at the right places and at the right moment of the year should reveal additional localities for this poorly known, disjunct Afro-American species.

All *Sphaerocarpos* species are dioicous and disperse by spore tetrads (over 100 μ m in diameter!). It is unlikely that the large tetrads are carried by wind, but dispersal by birds seems not unlikely in view of its occurrence on the shore of ponds and rivers.

II.b. Widely distributed element

37. *Exormotheca pustulosa* Mitt. (Exormothecaceae) (Plate VI/35)

According to BISCHLER (1976) *E. pustulosa* is the most widespread species of this subtropical-mediterranean genus to which about 7 species have been attributed (cf. also SCHIEFFNER 1942). *E. pustulosa* ranges from the western European mediterranean region to southern,

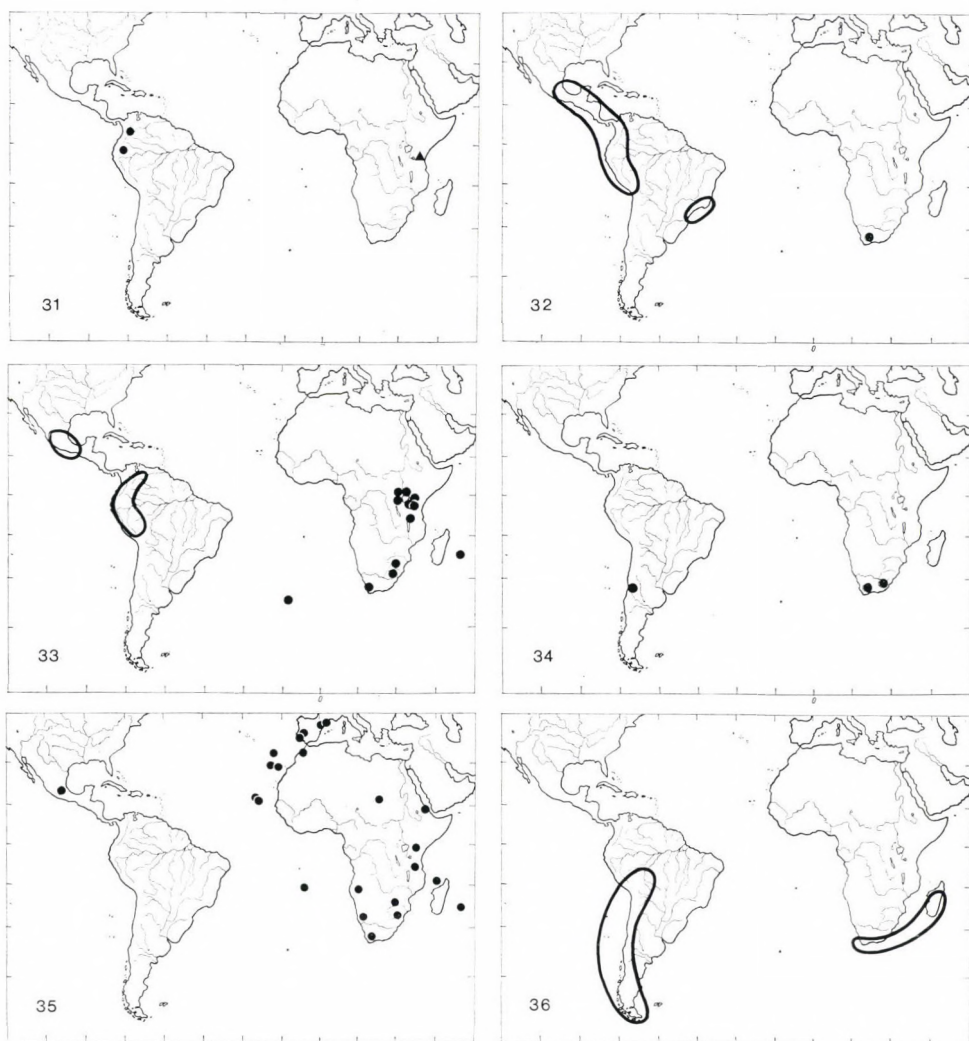


Plate VI

31–33: Tropical alpine. 34–35: Subtropical-Mediterranean and 36: Southern temperate species penetrating in tropical mountains. 31. *Colura ornithocephala* Herz. (dots) and *C. kilimanjarica* Pócs et S. J.-Ast (triangle). 32. *Gongylanthus liebmannianus* (Lindenb. et Gott.) Steph. (line) and *G. scariosus* (Lehm.) Steph. (dot). 33. *Lethocolea glossophylla* (Spruce) Grolle (line) and *L. congesta* (Lehm.) S. Arnell (dots). 34. *Sphaerocarpus stipitatus* Bisch. ex Lindenb. 35. *Exor-motheca pustulosa* Mitt. 36. *Heteroscyphus integrifolius* (Lehm. et Lindenb.) Fulf.

subtropical Africa, with localities also in tropical Africa near the coasts and on islands, especially those of the Atlantic Ocean. In tropical America a single recent locality is known, from Mexico (DÜLL in BISCHLER 1976: 771). The species is always terrestrial (incl. soil covered rocks) and occurs in habitats only temporarily moist. Microclimate and substrate conditions were described by BISCHLER (l.c.). It has probably been overlooked, being almost invisible during dry seasons and its range may be larger, especially in the temporarily dry tropics, than is

presently known. In tropical Africa it grows in xerophytic, rocky Velloziaceae bush or on the ground of miombo woodland (BIZOT and PÓCS 1979: 236), while the Mexican locality is from the soil of Mexico City Botanic Garden (R. DÜLL and R. GROLLE pers. comm.), which occurrence suggests the possibility of introduction. It occurs from sea level to 2300 m according to latitude.

E. pustulosa is autoicous (which fits its large range) and disperses by spores. In view of their large size (50–65 μm) wind dispersal should be less likely in this species. Vegetative reproduction is unknown.

III. TEMPERATE-SUBANTARCTIC AFRO-AMERICAN ELEMENTS

As argued by ENGEL (1978), this group of species is often unjustifiedly called “subantaretic” as their main range is in the southern temperate region following the definitions of recent phytogeographers (e.g. WACE, GREENE). Most of them penetrate northwards, some even through the tropics into the northern temperate region. Based on this criterium two elements can be distinguished:

III.a. Southern temperate element, with sporadic penetration into tropical mountains

The phenomenon, that southern temperate elements, often with Gondwanalandic origin, occur northwards in tropical mountains, is well known among phanerogams and widely discussed, especially in the case of páramo vegetation (e.g. CLEEF 1978). This type of migration was promoted by the upheaval and related climatic changes in the south-north oriented Andes (VAN DER HAMMEN et al. 1973), but in some cases occurred also in East Africa, where southern temperate elements penetrate in the more isolated high mountains (e.g. *Clasmatocolea vermicularis*, BIZOT and PÓCS 1974: 396). The phenomenon can be explained the same way. Even if the migration route from South to East Africa is not so continuous, a chain of montane areas can act as stepping stones, especially if we take in account the much more continuous and more depressed forest belts during pluvial periods, compared to the present (cf. COETZEE 1964, 1967).

38. *Clasmatocolea vermicularis* (Lehm.) Grolle (Geocalycaceae)

Clasmatocolea vermicularis was discussed in details and mapped by GROLLE (1960) and served also for FULFORD (1963) as an example for the above discussed distribution pattern. According to the very detailed data of GROLLE (l.c.) and to the new unpublished records of GRADSTEIN et al. it grows on different substrates, e.g. in Peru from 1300 m altitude, up to 4400 m in Bolivia; near sea level in temperate South America and on the subantarctic islands, from sea level to 700 m in Tristan da Cunha, from 300 to 1000 m in South Africa, finally at 1410 m in the highlands of Zimbabwe.

The above records were supplemented by new data from the high mountains of East Africa, as from the Rungwe Mts. in southern Tanzania, where *C. vermicularis* grows on earth banks (roadcut in volcanic ash) on the foot of Mt. Kyejo, a recent volcano, at 1725 m altitude (Bizor and Pócs 1974; 401) and from Rwanda: Gikungu and Burundi: Mt. Manga-Mugongo, Sikuvyaye and Nyakazu, collected by DE SLOOVER in montane forests, grasslands, on wet roadcut surface and on humid rocks, from 1700 to 2300 m altitudes (VÁŇA et al. 1979).

The species is dioicous and produces spores of 16–20 μm diameter. Gemmae were not observed.

One part of the East African localities (roadcut surfaces on young volcanic soil) suggests the possibility of easy dispersal over short distances, step by step way.

39. *Heteroscyphus integrifolius* (Lehm. et Lindenb.) Fulf. (Geocalycaceae) (Plate VI/36)

According to FULFORD (1976) the species occurs in the southern Andes (Patagonia, Chile, Tierra del Fuego) reaching to Peru and Bolivia and also Juan Fernandez. FULFORD (l.c.) also reported this species from Madagascar (type of *Lophocolea integrifolia* Steph.) and from South Africa, although ARNELL (1963) did not mention this species.

H. integrifolius is monoicous but sporophytes remain undescribed and no asexual means of reproduction is known.

40. *Hyalolepidozia bicuspidata* (Massal.) S. Arnell ex Grolle (Lepidoziaceae) (Plate VII/37)

The species is known from the southernmost edges of both continents and from Tristan da Cunha, from wet rock faces and from tree fern stems, among other hepatics according to ARNELL (1958) and FULFORD (1968), from sea level to about 700 m altitude.

It is dioicous and reproduces by spores. Both the small spores (12 μm in diameter) and the numerous thin stolons, which easily break off, seem to be adequate means of dispersal.

41. *Lepicolea ochroleuca* (Spreng.) Spruce (Lepicoleaceae) (Plate VII/38)

Lepicolea ochroleuca was originally described from South Africa (Cape) but is more widely distributed in Latin America, where it is known from two disjunct areas; the temperate-subantarctic tip of South America (Patagonia — Tierra del Fuego) where it grows near the sea level, and from the tropical mountains of Central America (Mexico to Honduras, FULFORD 1963), where it grows above 1600 m. Surprisingly, the species is not known from intermediate Andean regions, although there are unconfirmed, old records from Bolivia. As the species occurs on cool forest soil, over rock and on tree bark, there seems no reason, why it would be disjunct in the Latin American mountain range.

Lepicolea ochroleuca belongs to a putative primitive genus of liverworts, all species of which are dioicous. Female plants have been found occasionally but the sporophyte remains undescribed in this species. Asexual means of reproduction are unknown. Its present distribution and the lack of dispersal agents seem to suggest its relict character, a Gondwanalandic origin before its dissection and a secondary migration northwards up to Mexico, as it was suggested already by FULFORD (1963).

42. *Leptoscyphus expansus* (Lehm.) Grolle (Geocalycaceae) (Plate VII/39)

The genus *Leptoscyphus*, as delimited by GROLLE (1962), is mainly Afro-American in distribution (see also map 22) and has two centers of diversity: the tropical Andes and southern

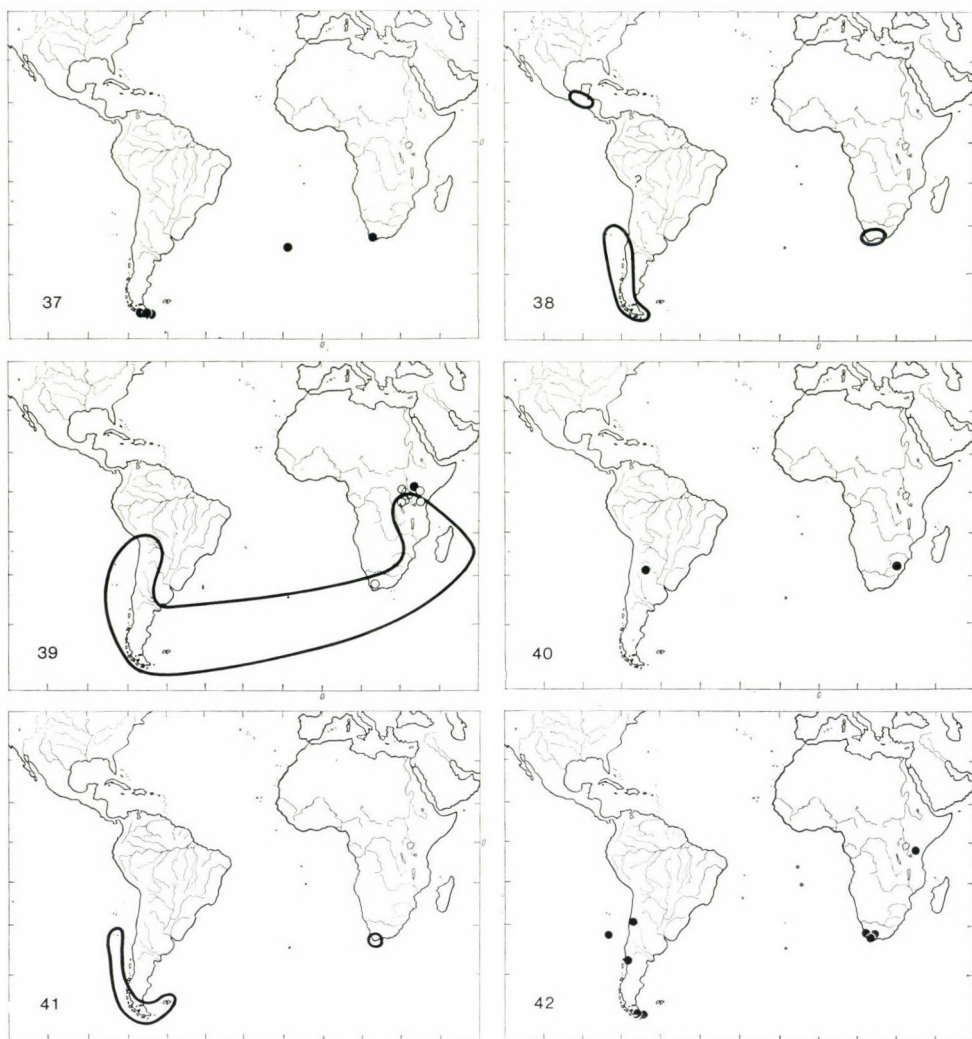


Plate VII

Southern temperate species with sporadic penetration into tropical mountains. 37. *Hyalolepidozia bicuspidata* (Massal.) S. Arnell ex Grolle. 38. *Lepicolea ochroleuca* (Spreng.) Spruce. 39. *Leptoscyphus expansus* (Lehm.) Grolle (solid line and black dot) and *L. hedbergii* (S. Arn.) Schust. (open rings). 40. *Lophozia argentina* (Steph.) Schust. 41. *Schistochila alata* (Lehm.) Schiffn. 42. *Tylimanthus limbatus* Steph.

tip of S. America and adjacent subantarctic islands. 19 species are known from tropical America (FULFORD 1976), only 6 species are growing in the African continent. Recently one undescribed species was discovered by R. MUES in New Zealand (genus named by GROLLE and VÁŇA), which seems to be closely related to *L. expansus*, but not conspecific. *L. expansus* is the only species occurring in each of the two continents. It is temperate-subantarctic ranging in South America from Tierra del Fuego to Bolivia (Comarapa, 2500 m) and in Africa from

Cape to Shaba (VANDEN BERGHE 1978), Rwanda (VÁŇA et al. 1979), and to Mt. Elgon, 3000 m altitude (coll. AGNEW, det. GROLLE, ined.). It is furthermore known from Madagascar and Mascareignes and from various subantarctic island groups (S. Georgia, Falkland I., Staaten I., Cape Horn), from Gough I. and Tristan da Cunha.

In southern S. America it is by far the most common species of the genus, growing extensively on soil, rotten logs and stumps in the deciduous and drier region in the evergreen forests (ENGEL 1978), where it is rather xerophytic. Of particular interest is its occurrence on tidal rocks in southern Chile where it tolerates salt water spray. The implications of this habitat for possible dispersal by sea currents were discussed by ENGEL and SCHUSTER (1973).

In tropical African mountains the species occurs in montane forests at ca. 2000–2500 m altitude. A closely related, robust vicariant, *L. hedbergii* (S. Arn.) Schust. occurs above 3200 up to 4000 m in the alpine regions of the East African mountains (one exceptional low record only from Mt. Kilimanjaro at 2500 m).

L. expansus is dioicous, but often fertile. It apparently lacks means of asexual reproduction.

43. *Lophozia argentina* (Steph.) Schust. (Jungermanniaceae) (Plate VII/40)

The species was known for a long time only on the basis of the type collection with uncertain locality (Argentina, coll. Lorentz); probably it is from the northern part of the country. Studying the African species of *Lophozia*, VÁŇA (1982) has found this species in the material collected by ESTERHUYSEN in Natal (Drakensberg) and erroneously recorded by S. ARNELL (1963), as *L. montaguensis* S. Arn. In Africa this species occurs "on cold wet rocky bank, S. aspect" at ca. 2500 m; as to the Argentinian locality ecological data are lacking.

Both populations are apparently dioicous and female (with perianths), but mature sporophytes were not yet seen.

44. *Schistochila alata* (Lehm.) Schiffn. (Schistochilaceae) (Plate VII/41)

Originally described from South Africa (leg. ECKLON), but more widely known from South America, where it occurs, according to ENGEL (1978) in Tierra del Fuego, the South Patagonian Channel region, on the Falkland Islands and, further north, on Juan Fernandez Is. (not on the adjacent Valdivian mainland). The species prefers wetter evergreen forests, where it is not uncommon at the base of large bryophyte mounds (ENGEL l.c.). Within the large, southern temperate — tropical montane genus (cf. SCHUSTER 1979) this is the only species with disjunct occurrence in America and Africa. A few species occur (partly *Paraschistochila*) in the tropical mountains of Africa, but, remarkably, the African distribution of *Schistochila* s.l. is restricted to the very old crystalline blocks and does not include the young volcanic mountains. In America no species penetrate into the tropical Andes. These facts coincide well with SCHUSTER's view (l.c.) on a very old, Gondwanalandic origin for *Paraschistochila* and *Schistochila* and even with the distribution of the above species, which is, most probably, incapable to long range dispersal, its present distribution marking previous land connections.

All species are dioicous but spores are frequently produced, their size is of 17–23 μ m in diameter. Gemmae are unknown in this species.

45. *Tylimanthus limbatus* Steph. (Acrobolbaceae) (Plate VII/42)

Syn.: *Marsupidium limbatum* (Steph.) Grolle; for further synonymy see ENGEL and GROLLE (1971).

This southern temperate Afro-American species (Tierra del Fuego to Northern Chile, Juan Fernández, S. Africa — see ENGEL and GROLLE l.c.) was recently discovered by JONES and PÓCS in the montane forests of Mt. Kilimanjaro (BIZOT and PÓCS 1974). Its disjunct occurrence on the geologically rather young Kilimanjaro volcano, where it grows in open, secondary *Myrica* forest, suggests arrival by long-range air dispersal. The possibility of a wider distribution of this species in East Africa, with occurrence for instance in the old block mountain range of Southeast Africa (intermediate between Mt. Kilimanjaro and South Africa) should not be ruled out.

The species is dioicous as all other representatives of the genus *Tylimanthus*, and may produce spores. About its mode of dispersal little remains known, however.

III.b. Wide southern temperate element, with penetration into tropical mountains and atlantic Europe

The seven species assigned to this group have a very interesting distribution pattern. They are more or less widespread in the southern temperate and subtropical zones and in the tropical montane belts of both continents, finally they irradiate to the atlantic islands, to Ireland and Britain or even to the western, oceanic part of continental Europe. Only two of them penetrate also into the atlantic, temperate coast of North America. It would be difficult to say, whether their present distribution (at least partly) reflects a Gondwanalandic origin and a European occurrence as the result of a later migration, or simply, a range to be explained by long range dispersal. All of them occur on the Macaronesian islands, which occurrence can be the relic of a former land bridge or even of a Tethyan distribution in the sense of Axelrod (1975); or these oceanic islands served, simply, as stepping stones in the way of the Gulf stream and air masses promoted by the sea current, which could carry diaspores from tropical America to atlantic Europe.

Anyway, based on their relationship, at least the two *Adelanthus* species, *Lepidozia cupressina* and *Telaranea nematodes* could have their origin on the former Gondwanaland, and taking in account the slow evolution in these groups, their dispersal could happen before its dissection. The two highly developed Lejeuneaceae taxa probably have another type of distributional history, in which long-range air dispersal might have played a much more important role.

46. *Adelanthus decipiens* (Hook. Mitt.) (Adelanthaceae)

This species, together with *A. lindenbergianus*, is discussed and mapped in detail by GROLLE (1969, 1972). Therefore we deal only briefly with them.

A. decipiens was not known until recently in the East African mountains, from where it was reported by BIZOT and PÓCS (1974, 1979) and by VÁŇA et al. (1979); it grows on Mt. Kahuzi, Kilimanjaro and in the Uluguru and Ukaguru Mts. at 2100–2900 m altitude, in the upper montane forest belt, as epiphyte or on rotten wood. It occurs also in the West African mountains, then in Transvaal and in South Africa (already at 660 m), on Tristan da Cunha

and St. Helena. It does not occur in the southern temperate tip of the American continent, only in the tropical Andes from Bolivia to Venezuela, in Costa Rica, on the Galapagos Islands (800 m!) and on the Antilles. Finally it reaches Europe through the Azores, where it occurs in Ireland, Britain and Finistère in France.

It is dioicous and often produces spores, therefore SCHUSTER (1979) suggests the possibility of transatlantic air dispersal.

47. *Adelanthus lindenbrogianus* (Lehm.) Mitt. (Adelanthaceae)

Its distribution pattern is very similar to the above species (see GROLLE 1969), but more southern in character. It is widespread in the temperate-subantarctic tip of South America, it occurs in the montane forests of the Andes and reaches Mexico as well (GROLLE 1972), but does not occur on the Antilles and in Macaronesia. It reaches Europe only in Ireland, but in Africa shows very similar distribution to that of *A. decipiens*, being widespread in the montane forests of East Africa and occurs in South Africa and in Lemuria but lacks in the West African mountains. It grows near the sea level (up to 700 m) in the temperate regions, while ascends up to 2100 m in the subtropics and up to 3900 m in the equatorial mountains. In the tropics it lives on bark, on shady rocks or on rotting logs of montane forests.

Dioicous species, producing 12–16 μm large spores. Vegetative reproduction is also known by gemmae, developing quite rarely on the apical part of the leaf margin. As the European populations are sterile, SCHUSTER (1979) suggests a recent arrival there via air transport of gemmae.

48. *Colura calyptrifolia* (Hook.) Dum. ssp. *calyptrifolia* (Lejeuneaceae) (Plate VIII/43)

Although VANDEN BERGHEM (1972a) stated, that *Colura tenuicornis* Evans differs only in quantitative characters from *C. calyptrifolia* and treated the two taxa, as subspecies of the latter, typical *C. calyptrifolia* has a very distinct distribution pattern (see also JOVET-AST 1954: 13–14). While *C. tenuicornis* (or *C. calyptrifolia* ssp. *tenuicornis*) is clearly pantropical in distribution, *C. calyptrifolia* is an oceanic-temperate Afro-American (+ European) species.

In addition to the knowledge about its distribution presented in the monograph of the genus by JOVET-AST (1953, 1954), *C. calyptrifolia* s. str. has become known also from Africa, from the tropical montane forests of Transvaal (ARNELL 1963: 178) and Tanzania (West Usambara Mts., Pócs ined.), and from the surrounding islands, as Tristan da Cunha (ARNELL 1958: 7) and from Mauritius (JONES 1979: 388).

Colura calyptrifolia is either epiphyllous or grows more often on twigs and bark of mostly ericaceous shrubs, in the tropical mountains between 1000 and 2000 m, while in oceanic-temperate areas near the sea level.

The plant is monoicous and produces large (40–65 \times 20–30 μm) spores and also abundant discoid gemmae.

49. *Lepidozia cupressina* (Sw.) Lindenb. (Lepidoziaceae) (Plate VIII/44)

If we treat the species in broad sense (Pócs 1984), by combining the many overlapping and transitional forms between related taxa treated separately many times, it has a tricentric distribution pattern. In America it is widespread from the southern subantarctic and temperate zones through the Andes to the Caribbean region. In Africa it is known from subtropical Cape through Natal and Transvaal to the mountains of East Africa, finally from

the Mascarenes to Atlantic Europe including a small part of Norway with very oceanic climate. The most primitive forms are known at the temperate parts of South America and in South Africa, while in the Andes and East African mountains and in Atlantic Europe a secondary evolution took place at subspecies level, which well reflects a Gondwanalandic origin.

In the tropical mountains *L. cupressina* occurs on the acid ground and on the bark of trees of montane evergreen forests between 1000 and 3000 m altitude, sometimes penetrating in the tropic alpine vegetation up to 3600 m. On the other hand, it descends near to sea level in the temperate zones.

Lepidozia cupressina is dioicous and reproduces by spores, but sporophytes do not develop too often. Asexual means of propagation is not known.

50. *Leptosecyphus cuneifolius* (Hook.) Mitt. (Geocalycaceae)

The taxonomy and distribution of this species are thoroughly discussed by GROLLE (1962), accompanied by a map. More recent records are enumerated by SCHUSTER (1980: 278). The species is more or less bipolar in distribution. In the northern hemisphere it occurs on both sides of the Atlantic Ocean; in the Appalachians of eastern USA, in the Azores, Madeira, Ireland and Great Britain and SE Norway. It penetrates in the tropical region in the Caribbean, where it becomes an inhabitant of montane evergreen forests, as in Cuba (VÁŇA ined.), Jamaica, Dominica, Mt. Roraima in Guyana and in the Venezuelan and Colombian Andes, where it grows between 3000 and 3500 m (GRADSTEIN and HEKKING 1979). In the southern hemisphere it occurs quite isolated from the northern population, being widespread from Juan Fernandez Is. to the Magellan Strait and in Tristan da Cunha. In his monograph of *Leptosecyphus* GROLLE (l.c.) distinguished the southern population as ssp. *fragilis* (Jack et Steph.) Grolle, but later synonymized it with the typical subspecies, which was confirmed by SCHUSTER (l.c.). It is remarkable, that the species does not reach the eastern world sector in continental Africa (only Atlantic islands and Europe), although, being such a delicate plant, it could easily have been overlooked in African material.

In the Southern Appalachian Mts. it grows in fog forests on the bark of *Abies fraseri* (SCHUSTER l.c.), while in Cuba lives in montane evergreen mist forests (fangales, monte nublado) on bark of trees, at 1100 m altitude (PÓCS ined.). On other Caribbean islands and in Colombia it is known as a ramicolous species in the mossy forests and shrubs of higher mountains, while in Chile it occurs on the bark of *Nothofagus* trees (SCHUSTER 1980: 279). On the Azores, according to SJÖGREN (1978) it is known as epiphyte or epilithic, usually growing intermixed in dense moss carpets of *Juniperus brevifolia* forests. The above habitats and the oceanic distribution of the species reflect its high demand on atmospheric humidity.

Dioicous species, rarely producing spores, but asexual means of reproduction by caducous leaves and underleaves is always present.

51. *Lejeunea* (*Microlejeunea*) *ulicina* (Tayl.) Tayl. complex (*Lejeunea*-ceae) (Plate VIII/45)

It depends on the species concept used, whether we treat this complex, as members of a subtropical-tropical vicariant species pair or as two subspecies of a northern temperate species, *Lejeunea ulicina*. As SCHUSTER dealt in details with the delimitation of the taxa belonging here (SCHUSTER 1962, 1979: 1067), involving statistics made on many specimens belonging to this complex. We accept his concept, treating the taxa concerned as subspecies. This case there are three subspecies at hand;

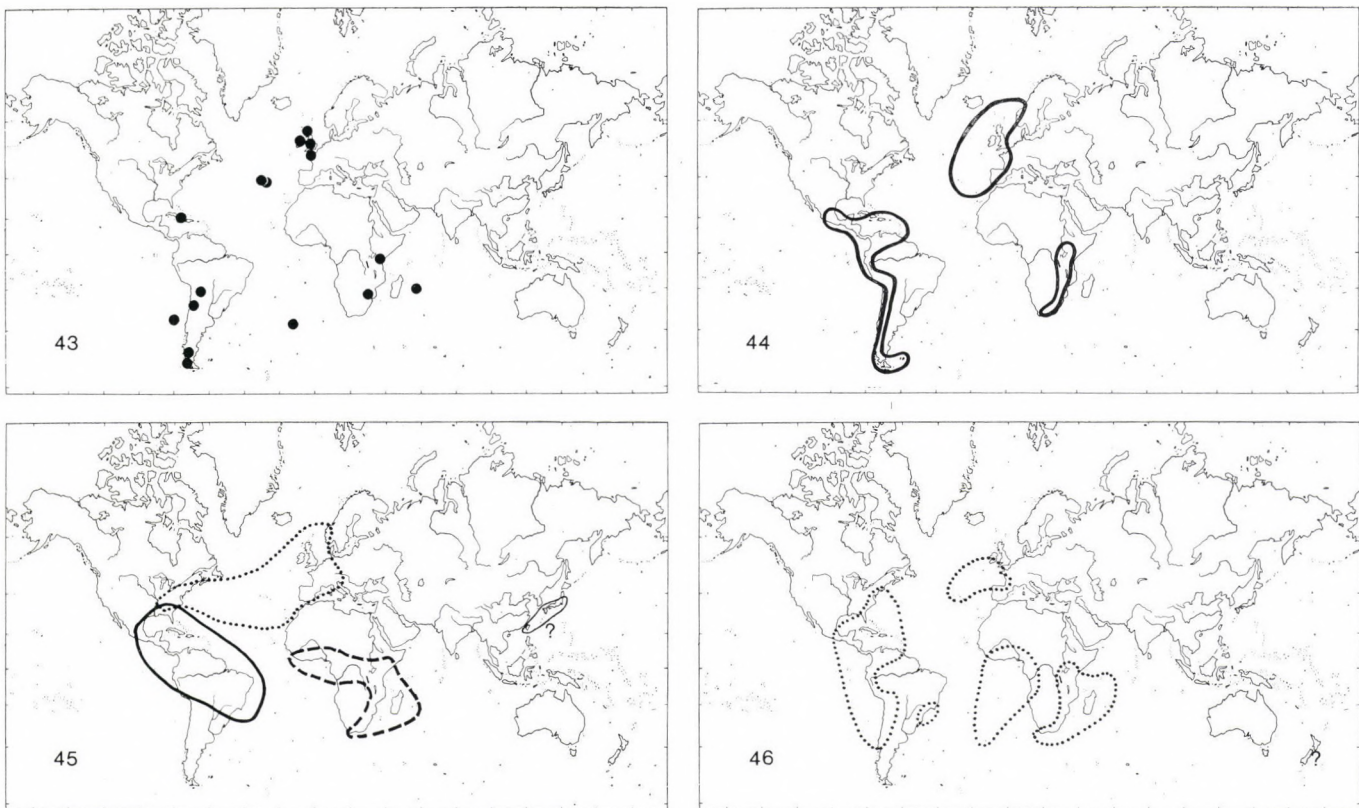


Plate VIII

Southern temperate species in wide sense, penetrating into atlantic Europe. 43. *Colura calyptrifolia* (Hook.) Dum. 44. *Lepidozia cupressina* (Sw.) Lindenb. 45. *Lejeunea* (*Microlejeunea*) *ulicina* (Tayl.) Tayl. ssp. *ulicina* (dotted line), ssp. *bullata* (Tayl.) Schust. (solid line) and ssp. *ocellifera* (S. Arnell) Schust. (broken line). (Thin line marks Japanese populations of *L. punctiformis* Tayl. assigned to *L. ulicina* ssp. *ulicina* by Schuster and Inoue.) 46. *Telaranea nematodes* (Gott. ex Aust.) Howe. ?: *T. herzogii* (Hodgs.) Hodgs. with obscure relation to *T. nematodes*

a) *Lejeunea ulicina* (Tayl.) Tayl. ex G., L. et N. ssp. *ulicina*

Distributed on both sides of the Atlantic Ocean, in the areas affected by oceanic climate and growing on rocks and bark, on rotting wood or rarely on living bryophytes, in dense (mostly deciduous) forests up to 1800 m altitude. According to SCHUSTER (l.c.) some Japanese populations assigned to *L. punctiformis* are also referable to this ssp. INOUE in his recent paper (1981) seems to accept and even extend the presence of *L. ulicina* in Japan and to the whole area formerly known as of *L. punctiformis* in Southeast Asia.

b) ssp. *bullata* (Tayl.) Schust.

Syn.: *Lejeunea bullata* Tayl.

Microlejeunea bullata Evs.

(See further synonymy in SCHUSTER 1980: 1074)

Its area just overlaps that of the first subspecies in the southeastern United States and it is widespread in the Caribbean region and the northern half of South America. It occurs both as corticolous and epiphyllous, rarely also on rocks or on ground, up to 3000 m in tropical America (BISCHLER et al. 1963).

c) ssp. *ocellifera* (S. Arnell) Schust.

Syn.: *Microlejeunea africana* Steph.

Microlejeunea ocellifera S. Arnell

Very common and widespread in the wetter parts of tropical and South Africa, where it occurs from the sea level up to 2100 m in the lowland and montane forests belts, first of all, as epiphyllous and corticolous species. According to JONES (1969) it occurs in the lowland rain forests of West Africa, where it is very common, usually on the bark of tree boles and branches.

All subspecies are dioicous (if *L. punctiformis* separately exists) and often produce perianths, while the sporophytes are unknown. As no kinds of asexual propagation are at hand, it remains obscure, how the species can be such a successful pioneer on shady, wet bark or living leaves, not mentioning the very large area of distribution. One must think about vegetative propagation by fragmentation and easy survival of the detached plant fragments.

52. *Telaranea nematodes* (Gott. ex Aust.) Howe (Lepidoziaceae) (Plate VIII/46)

T. nematodes has a distribution pattern very similar to that of the previous 6 species, but conspicuous by its penetration into the temperate region of USA as north as to New York (SCHUSTER 1969). Following the atlantic coast line, it becomes very widespread in the Caribbean region, in the tropical Andes and occurs again in the south Brazilian highlands. In Africa it is bicentric, occurring in the Guinea-Congo rain forest basin and South-East Africa including Madagascar and the Mascarene islands. It should be checked, whether *Telaranea herzogii* (Hodgs.) Hodgs. in New Zealand is only closely related or conspecific with it. *T. nematodes* occurs in Europe only along the warm-temperate, oceanic coast.

In the wettest tropics, like in the upper Amazonas or Congo basin, it occurs even near the sea level, growing together with *Arachniopsis diacantha*, which is similar in appearance. It is quite common in tropical montane forests up to about 2000 m altitude and penetrates even in the páramo vegetation belt (up to 4250 m in Colombia!, GRADSTEIN and HEKKING 1979). It grows usually on acid ground, rotten wood or on litter, on peaty soil of bogs, rarely on rock surface, usually associated with other Lepidoziaceae species.

It is dioicous and often produces spores (14–17 μ m in diameter). Asexual reproduction is not known.

Discussion

Taxonomic relations

The greatest part of disjunct, bicontinental lowland tropical taxa belongs to the family of Lejeuneaceae, while other patterns are found in other, mainly Jungermannialean groups, from throughout various families except *Plagiochila*. This may illustrate the high level of regional speciation within this giant genus undergoing present evolution.

Among thallose liverworts there are only very few examples (*Aneura pseudopinguis*, *Metzgeria albinea* still incompletely known and not discussed), but significantly the subtropical disjuncts are exclusively thallose (*Exormotheca*, *Sphaerocarpos*), which relates to the dominance of thallose taxa in these areas. A large genus, in which macro-disjuncts are rare (like in *Plagiochila*) may be *Riccardia* (no evidence found thus far, fide JAN MEENKS who checked material from both continents).

The above conclusions also hold for the Afro-Asiatic and pantropical taxa (see lists in BIZOT and PÓCS 1974, PÓCS 1976 and unpublished records). The total number of macrodisjunct tropical liverwort species known is now about 95 in Africa (40 Afro-Asian; 35 Afro-American; 20 pantropical).

Ranges

The maps show continuous or discontinuous distribution patterns on each continent. Continuous distribution is seen mostly in case of tropical lowland species, like *Acrolejeunea emergens*, *Radula flaccida*. Discontinuous areas are much more common, the reasons are:

1. *Ecological barriers*: in the case of most montane and alpine elements or, even, by lowland rain forest elements occurring in a generally drier environment with isolated forest patches, like in case of *Pycnolejeunea contigua* in East Africa. The montane taxa are potentially quadricentric: Andes with the West Indies, SE Brasil; West Africa (local), finally East and South Africa with the Lemurian islands. *Radula boryana* and *Symphyogyna brasiliensis* have almost "complete quadricentric" ranges, while others miss from one or two of these centres. Reason may be insufficient exploring (see below). The alpine taxa are usually bicentric: Andes and East African high mountains (*Andrewsianthus jamesonii* or *Gymnocoleopsis multiflora*). When their altitudinal range extends to the montane belt as well, their distribution becomes larger (e.g. *Herbertus subdentatus*). *Isotachis aubertii* is unexpectedly lacking from the Andes and the reason may be also insufficient exploration.

2. *Insufficient exploring*: ranges for the tiny and possibly overlooked *Aphanolejeunea exigua*; the crown epiphyte *Lejeunea uncioloba*; species growing in habitats often ignored by non-specialist, like shaded banks (*Andrewsianthus*

jamesonii) or species visible in dry areas only during the rainy season not favoured by visiting botanists.

3. *Insufficient taxonomic knowledge*: although the fragmentary range *Lejeunea autoica* is explainable by a possible polytopic evolution, it is much more reasonable, that this species is still hidden among the many unrevised materials belonging to the taxonomically difficult genus *Lejeunea*. This may be the reason also for the very fragmentary knowledge about the American distribution of *Aneura pseudopinguis* and some other taxa.

4. *Relict distribution relating to Gondwanic origin*: potential habitats for such genera, as *Bryopteris* and *Symbiezidium* are plentiful on the African mainland, yet lacking there. The very restricted ranges of *Arachniopsis disotricha* and the vicariant *A. diplopoda* are to be explained also by their relict character. The case of "peri-Afro-american element" was discussed in detail for *Symbiezidium*, on page 140 as the case of species restricted to geologically old mountains, not being capable to long-range dispersal, as well (Pócs 1982, VAN ZANTEN and PÓCS 1981, and by *Schistochila alata* on page 157 of this paper).

5. *Unknown reasons*: for example in the case of *Stephaniella paraphyllina*, which is widespread in the Andean region, it is obscure, why it does occur only at a single place in Africa, where similar environmental conditions are assured at many places. The African locality could be explained by one single successful case of long-range air dispersal but also by the relict character of a former wider distribution in Africa. There are no indications that the species might have been introduced by man, as in the case of the Mexican locality of *Exormotheca pustulosa*.

Dispersibility

The ability for long-range or short-range air dispersal, or step by step land dispersal is the main factor, which can influence the range of species and is responsible for disjunct distribution along the dissection of land masses and along other geological and climatic changes. The dispersibility of species depends upon several factors (see also Introduction):

1. *Sexuality*: almost all disjunct Lejeuneaceae are autoicous. Within *Acrolejeunea* the widespread spp. are autoicous, local spp. normally dioicous (GRADSTEIN 1975). The single dioic species among Afro-American tropical lowland element is *Radula flaccida*, which has copious gemmae.

Contrasting with tropical lowland species, montane, alpine and other spp. are mainly dioicous, although some may develop gemmae (*Andrewsianthus jamesonii*). It seems that the dioicous condition is more common in temperate species. Yet, in all spp. sporophytes occur, so long-range dispersal via uni-

sexual spores may still be possible, although the chances for successful establishment are lower. It can be concluded, that sexuality is not evidently reduced in the macro-disjunct species contrary to local, endemic liverworts.

2. *Asexual reproduction and dispersal by fragmentation*: on the whole, only few spp. (ca 25%) have special asexual means of reproduction (gemmae, cladulae). Fragmentation might be very important in the alpine species (*Stephaniella*, *Marsupella*), which often grow on loose, dry, bare ground of open plant communities. There are observations on byrophyte fragments successfully germinated after melting from arctic icefields, which seems to prove the survival ability of liverwort fragments under dry and low temperature conditions.

3. *The resistance of diaspores*: as VAN ZANTEN and PÓCS (1981) discussed in details, we know much about the drought and cold resistance of moss spores, but much less about that of the liverworts. According to FULFORD (1951) protonematal spores of Lejeuneaceae are little resistant and not suitable for long-range dispersal. However, this has not been tested, although she experienced, that even one hour exposure under laboratory air conditions killed the spores of Lejeuneaceae, *Lepidozia* and *Ptilidium*.

4. *Spore size*: as mentioned in the Introduction, diaspores must be small enough for aerial transport. Checking our Afro-American liverwort species from this point of view (not the vicariant species pairs and Afro-American genera), only 14 species fall in the category of sizes apt for easy long-range air transport, the spore size in eight species being definitely much larger than 25 μm and in 15 species unknown. Asexual gemmae are also to be tested from this point of view.

5. *Suitable habitat and competing ability*: from this point of view "weedy" species occurring often on bare surfaces, as recent lava rocks, roadcuts or, as epiphytes, in secondary habitats (isolated palms and orchard trees, plantations, forest openings) are such, which one should expect to have arrived by long-range air transport and aggressive enough to compete with other species. To a large extent, "weedy" often correlates with commonness (cf. GRADSTEIN and WEBER 1982: 134) and many species among the disjuncts fall in this category being at least locally weedy: *Acrolejeunea emergens*, *Cololejeunea cardiocarpa*, *Herbertus subdentatus*, *Isotachis aubertii*, *Lophocolea martiana*, *Schiffneriolejeunea polycarpa*, *Symphyogyna brasiliensis*, etc. On the other hand, many common, "weedy" species are not bicentric disjunct and apparently restricted to one continent only, as the American *Dicranolejeunea axillaris*, *Frullania brasiliensis*, *Leptolejeunea elliptica*, *Leptoscyphus porphyrius* or *Plagiochila guilleminiana* and the African *Cololejeunea pusilla*, *Frullania caffraria*, *Marchantia parviloba* or *Plagiochila terebrans*. These may be "chance endemics" in the sense of ZANTEN (1978: 471), if their diaspores are apt for long-range air dispersal.

The occurrence of such species on isolated, \pm young oceanic islands seems to confirm their air dispersal. From the discussed Afro-American species *Symphyogyna brasiliensis* (Ascension, Tristan da Cunha), *Syzygiella concreta* (Tristan), *Isotachis aubertii* (Ascension), *Exormotheca pustulosa* (St. Helena), *Leptoscyphus expansus* (Tristan), *Hyalolepidozia bicuspidata* (Tristan), the two *Adelanthus* (Tristan), *Colura calyptrifolia* and *Telaranea nematodes* (Tristan) and some others occur on the islands along the Atlantic ridge. Most of these are weedy on the mainland, hence aggressive which should have helped their dispersal on the not too old volcanic islands.

Final conclusion

Most Afro-American species seem to be common in parts of their ranges and thus well capable to step by step dispersal. Even though in some spp. we find few indications of copious diaspore production, an occasional or isolated case of long-range air dispersal could well be assumed as having caused the

Table 3

A listing of further supposed tropical Afro-American vicariant species pairs, partly of unverified taxonomic status

American taxa	African taxa
<i>Archilejeunea</i> spp.	<i>Archilejeunea africana</i> Steph. and allies
<i>Brachiolejeunea chinantlana</i> (Gott.) Schiffn.	<i>Brachiolejeunea tristis</i> Steph.
<i>Calypogeia peruviana</i> Nees et Mont.	<i>Calypogeia afrocoerulea</i> E. W. Jones
<i>Calypogeia cellulosa</i> (Spreng.) Steph.	<i>Calypogeia fusca</i> (Lehm.) Steph.
<i>Caudalejeunea lehmanniana</i> (Gott.) Evans	<i>Caudalejeunea hanningtonii</i> (Mitt.) Schiffn. and allies
<i>Cololejeunea bischlerana</i> Tixier	<i>Cololejeunea hyalino-marginata</i> (Nees et Mont.) Grolle
<i>Cylindrocolea rhizantha</i> (Mont.) Schust.	<i>Cylindrocolea atroviridis</i> (Sim) Váňa
<i>Drepanolejeunea bidens</i> Steph.	<i>Drepanolejeunea cultrella</i> (Mitt.) Steph.
<i>Frullania riojaneirensis</i> (Raddi) Ångstr.	<i>Frullania africana</i> Steph.
<i>Lophocolea trapezoidea</i> Mont.	<i>Lophocolea muhavurensis</i> (S. Arn.) S. Arn.
<i>Marchesinia brachiata</i> (Sw.) Schiffn.	<i>Marchesinia excavata</i> (Mitt.) Steph. and allies
<i>Marsupella trollii</i> Herz.	<i>Marsupella capensis</i> S. Arn.
<i>Odontolejeunea lunulata</i> (Web.) Schiffn.	<i>Odontolejeunea tortuosa</i> (L. et L.) Steph.
<i>Pallavicinia erythropus</i> (Gott.) Steph.	<i>Pallavicinia spinosa</i> (L. et L.) Grolle
<i>Plagiochila columbica</i> Gott.	<i>Plagiochila integerrima</i> Steph.
<i>Porella swartziana</i> (Web.) Trev.	<i>Porella capensis</i> (Gott.) Steph.
<i>Rectolejeunea pililoba</i> (Spr.) Schust.	<i>Rectolejeunea setacea</i> (Steph.) Schust.

macro-disjunction. In some other cases production of diaspores apt for long-range air dispersal is apparently lacking. It is hard to visualize that evolution went so slow in these "successful" species, that they did not evolve since the breaking up of western Gondwanaland. However, this could have caused very well the disjunction of genera, the vicariant species pairs in many cases and in some, exceptional cases the disjunction of species in archaic groups, where evolution remained slow. Fossil finds in amber (GROLLE 1981) confirm that eocenic species belong to still existing genera and that "Ginkyo-type" relict occurrences may be present even in "advanced" groups of liverworts, as *Nipponolejeunea* (Japan; fossil also in Europe).

A correlation with level of evolutionary advancement, as SCHUSTER (1969) postulates for the southern temperate regions, needs more taxonomic and floristic data than currently available for the tropics, hence results in too much unfounded speculation. Also, it needs to focus on all types of ranges (including the endemic), not just the macro-disjuncts.

Further research should involve taxonomic work on supposed vicariant species pairs (e.g. Table 3), strenghtening the arguments and explanations when more examples appear. Also, we have to know much more about the resistance and dispersal ability of Hepatic diaspores, proved by experiments. Of course, any increase of the meagre paleontological evidence might help in the understanding of liverwort dispersal in relation to their evolution and to the geological events.

REFERENCES

- Anderson, L. E. (1963): III. Modern species concept: mosses. *Bryologist* **66**: 107–119.
 Anderson, L. E. (1974): Bryology 1947–1972. In: 25 years of Botany. *Ann. Missouri Bot. Garden* **61**: 56–85.
 Arnell, S. (1956): Hepaticae collected by O. Hedberg et al. on the East African Mountains. *Arkiv f. Bot.* **3**: 517–562.
 Arnell, S. (1958): Hepatics from Tristan da Cunha. *Res. Norw. Sci. Expedition to Tristan da Cunha 1937–1938*, **42**: 1–76.
 Arnell, S. (1963): *Hepaticae of South Africa*. Norstedt and Söner, Stockholm, 411 pp.
 Arnell, S. (1965): Hepaticae collected by Mr. Gillis Eeen in Mauritius and Réunion in 1962. *Svensk Bot. Tid.* **59**: 65–84.
 Axelrod, D. I. (1975): Evolution and biogeography of Madrean-Tethyan sclerophyll vegetation. *Ann. Missouri Bot. Garden* **62**: 280–334.
 Bischler, H. (1976): *Exormotheca pustulosa* Mitten. Distribution, écologie, caryotype, spores, paroies sporales, germination. *Rev. Bryol. Lichénol.* **42**: 769–783.
 Bischler, H., Bonner, C. E. B., Miller, H. A. (1963): Studies in Lejeuneaceae IV: The genus *Microlejeunea* Steph. in Central and South America. *Nova Hedwigia* **5**: 359–411 + 11 t.
 Bizot, M., Pócs, T. (1974): East African Bryophytes, I. *Acta Acad. Paed. Agriensis, nov. ser.* **12**: 383–449.
 Bizot, M., Pócs, T. (1979): East African Bryophytes, III. *Acta Bot. Acad. Sci. Hung.* **25**: 223–261.
 Bizot, M., Pócs, T. (1982): East African Bryophytes, V. *Acta Bot. Acad. Sci. Hung.* **28**: 15–64.
 Borhidi, A. (1982): Die Entwicklung der Flora der Antillen im Lichte der Kontinentalverschiebungstheorie. *Stappia* **10**: 235–241.
 Castle, H. (1936): A revision of the genus *Radula*. Introduction and Part I: *Cladoradula*. *Ann. Bryol.* **9**: 13–56.

- Castle, H. (1939): Ibid. Part II: subgenus *Acroradula*. *Ann. Bryol.* **12**: 21–47.
- Castle, H. (1968): *Radula* (L.) Dumortier. — A synopsis of the taxonomic revision of the genus. *Rev. Bryol. Lichénol.* **36**: 5–44.
- Cleef, A. M. (1978): Characteristics of Neotropical páramo vegetation and its subantarctic relations. In: Geocological relations between the southern temperate zone and the tropical mountains. (Eds: C. Troll and W. Lauer.) *Erdwissenschaftlicher Forschung* (Wiesbaden) **11**: 365–390 + 6 t.
- Coetzee, J. A. (1964): Evidence for a considerable depression of the vegetation belts during the upper Pleistocene of the E. African mountains. *Nature* **204**: 564–566.
- Coetzee, J. A. (1967): Pollen analytical studies in east and southern Africa. In: *Palaeoecology of Africa and the Surrounding Islands and Antarctica*, **3**: 1–146. Balkema, Cape Town and Amsterdam.
- Crosby, M. R. (1976): Trois mousses (Hookeriaceae) nouvelles pour la flore malgache. *Rev. Bryol. Lichénol.* **42**: 711–714.
- Crum, H. (1972): The geographic origins of the mosses of North America's eastern deciduous forest. *J. Hattori Bot. Lab.* **35**: 269–298.
- Crundwell, A. C. (1970): *Herberta borealis*, a new species from Scotland and Norway. *Trans. Brit. Bryol. Soc.* **6**: 41–49.
- Cuatrecasas, J. (1954): Outline of vegetation types in Colombia. *8. Congr. Intern. Bot. Rapp. and Comm. Sect.* **7**: 77–78.
- Engel, J. J. (1978): A taxonomic and phytogeographic study of Brunswick Peninsula (Strait of Magellan) — Hepaticae and Anthocerotae. *Fieldiana Bot.* **41**: 1–319.
- Engel, J. J., Schuster, R. M. (1973): On some tidal zone Hepaticae from South Chile, with comments on marine dispersal. *Bull. Torrey Bot. Club* **100**: 29–35.
- Evans, A. W. (1905): New or notheworthy Hepaticae from Florida. *Bull. Torrey Bot. Club* **32**: 179–192 + 5 t.
- Evans, A. W. (1911): Hepaticae of Puerto Rico, X. *Cololejeunea*, *Leptocolea* and *Aphanolejeunea*. *Bull. Torrey Bot. Club* **38**: 251–286 + 2 t.
- Evans, A. W. (1912): Hepaticae of Puerto Rico, XI. *Diplasiolejeunea*. *Bull. Torrey Bot. Club* **39**: 209–224 + 2 t.
- Frahm, J.-P. (1982): Grossdisjunktionen von Arealen südamerikanischer und afrikanischer *Campylopus*-Arten. *Lindbergia* **8**: 45–52.
- Fryxell, P. A. (1967): The interpretation of disjunct distributions. *Taxon* **16**: 316–324.
- Fulford, M. H. (1951): Distribution patterns of the genera of leafy Hepaticae of South America. *Evolution* **5**: 243–262.
- Fulford, M. H. (1963): Continental drift and distribution patterns in the leafy Hepaticae. In: Polar Wandering and Continental Drift. *Soc. Econ. Paleontol. and Mineral. spec. paper* **1D**: 140–145.
- Fulford, M. H. (1963–1976): Manual of the leafy Hepaticae of Latin America, I–IV. *Mem. New York Bot. Garden* **11**: 1–535.
- Geissler, P., Greene, S. W. (ed.) (1982): Bryophyte Taxonomy, methods, practices and floristic exploration. *Proc. Inter. Ass. Bryol. Taxonomic Workshop Meeting, Genève* 27 Aug.–2 Sept. 1979. *Beih. Nova Hedwigia* **71**: 1–588.
- Gottsche, C. M., Lindenberg, J. B. G., Nees von Esenbeck, C. G. (1844–1847): *Synopsis Hepaticarum*. Meissner, Hamburg, 834 pp.
- Gradstein, S. R. (1974): Studies on Lejeuneaceae Subfam. Ptychanthoideae, I. Nomenclature and taxonomy of *Ptychocoleus*, *Acrolejeunea* and *Schiffneriolejeunea*. *J. Hattori Bot. Lab.* **38**: 327–336.
- Gradstein, S. R. (1975): A Taxonomic Monograph of the Genus *Acrolejeunea* (Hepaticae) with an arrangement of the Genera of Ptychanthoideae. *Bryoph. Bibliotheca* **4**: J. Cramer, Vaduz, 162 pp. + 24 t.
- Gradstein, S. R., Cleef, A. M., Fulford, M. H. (1977): Studies on Colombian cryptogams, II. Hepaticae — Oil body structure and ecological distribution of selected species of tropical Andean Jungermanniales. *Proc. Kon. Ned. Acad. Wetensc. ser. C.* **80**: 377–420 + 5 t.
- Gradstein, S. R., Hekking, W. H. A. (1979): Studies on Colombian cryptogams, IV. A catalogue of the Hepaticae of Colombia. *J. Hattori Bot. Lab.* **45**: 93–144.
- Gradstein, S. R., Inoue, H. (1980): Studies on Lejeuneaceae Subfam. Ptychanthoideae, V. A review of the species of Ceylon. *Bull. Nat. Sci. Mus., Ser. B (Bot.)* **6**: 23–32.
- Gradstein, S. R., Weber, W. A. (1982): Bryogeography of the Galapagos Islands. *J. Hattori Bot. Lab.* **52**: 127–152.
- Grolle, R. (1960): Nachtrag zur "Revision der Clasmatocolea-Arten". *Rev. Bryol. Lichénol.* **29**: 68–91.

- Grolle, R. (1969): Monographie der Lebermoosgattung *Leptoscyphus*. *Mitt. Nova Acta Leopoldina n. ser.* **25**: 2–143.
- Grolle, R. (1969): Grossdisjunktionen in Artenarealen Lateinamerikanischer Lebermoose. In: *Biogeography and Ecology in South America* (ed. Fittkau et al.). W. Junk, The Hague, 562–582.
- Grolle, R. (1972): Zur Kenntnis von *Adelanthus* Mitt. *J. Hattori Bot. Lab.* **35**: 325–370.
- Grolle, R. (1975): *Haplolejeunea* aus Madagascar — eine weitere neue Gattung der Tuyamaelloideae. *J. Hattori Bot. Lab.* **39**: 203–210.
- Grolle, R. (1978): Die Lebermoose der Seychellen. *Wiss. Ztschr. Friedrich-Schiller-Univ. Jena, Math.-Nat. R.* **27**: 1–17.
- Grolle, R. (1979): Miscellanea hepaticologica 171–180. *J. Bryol.* **10**: 263–272.
- Grolle, R. (1979): Miscellanea hepaticologica 181–190. *J. Hattori Bot. Lab.* **45**: 173–183.
- Grolle, R. (1980): Miscellanea hepaticologica 201–210. *J. Bryol.* **11**: 325–334.
- Grolle, R. (1981): Miscellanea hepaticologica 211–220. *J. Hattori Bot. Lab.* **49**: 85–92.
- Hammen, T. van der, Dommelen, H. van (1973): Palynological record of the upheaval of the Northern Andes: a study of the Pliocene and Lower Quaternary of the Colombian Eastern Cordillera and the early evolution of its highandean biota. *Palaeogeogr. Palaeoclim. Palaeoecol.* **16**: 1–24.
- Hässel de Menendez, G. G. (1962): Estudio de las Anthocerotales y Marchantiales de la Argentina. *Opera Lilloana* **7**: 1–297.
- Hatcher, R. E. (1960–1961): A monograph of the genus *Isotachis* (Hepaticae), I. *Nova Hedwigia* **2**: 573–608; II. *Nova Hedwigia* **3**: 1–35.
- Hedberg, O. (1951): Vegetation belts of the East African mountains. *Svensk Bot. Tid.* **45**: 140–202.
- Herzog, Th. (1926): *Geographie der Moose*. G. Fischer, Jena, 439 pp. + 8 t.
- Inoue, H. (1966): A monograph of the Hepatic genus *Syzygiella* Spruce. *J. Hattori Bot. Lab.* **29**: 171–213.
- Inoue, H. (1981): Hepaticae of Mt. Fuji, Central Japan. *Mem. Nat. Sci. Mus., Tokyo* **14**: 59–74.
- Jones, E. W. (1953): African Hepatics, V. *Lophocolea*, with notes on *Chyloscyphus* and *Leptoscyphus*. *Trans. Brit. Bryol. Soc.* **2**: 172–202.
- Jones, E. W. (1954): African Hepatics, VII. *Diplasiolejeunea albifolia* (Taylor) E. W. Jones comb. nov. *Trans. Brit. Bryol. Soc.* **2**: 393–407.
- Jones, E. W. (1956): African Hepatics, XI. The genus *Riccardia* in tropical Africa. *Trans. Brit. Bryol. Soc.* **3**: 74–84.
- Jones, E. W. (1963): African Hepatics, XVI. *Porella* in tropical Africa. *Trans. Brit. Bryol. Soc.* **4**: 446–461.
- Jones, E. W. (1969): African Hepatics, XXI. *Microlejeunea*, *Chaetolejeunea* and *Pleurolejeunea*. *Trans. Brit. Bryol. Soc.* **5**: 775–789.
- Jones, E. W. (1973): African Hepatics, XXIV. Lejeuneaceae: some new or little-known species and extensions of range. *J. Bryol.* **7**: 545–561.
- Jones, E. W. (1974): African Hepatics, XXV. *Rectolejeunea*. *J. Bryol.* **8**: 71–75.
- Jones, E. W. (1976): African Hepatics, XXIX. Some new or little-known species and extensions of range. *J. Bryol.* **9**: 43–54.
- Jones, E. W. (1977): African Hepatics, XXX. The genus *Radula* Dumortier. *J. Bryol.* **9**: 461–504.
- Jones, E. W. (1979): African Hepatics, XXXI. Some new or little-known Lejeuneaceae and extensions of range. *J. Bryol.* **10**: 387–400.
- Jovet-Ast, S. (1948): Les mousses et sphaignes de Madagascar. *Mém. Inst. Sci. Madag. Sér. B* **1/2**: 43–56.
- Jovet-Ast, S. (1953): Le genre *Colura*. Hépatiques. Lejeuneaceae, Diplasiae. *Rev. Bryol. Lichénol.* **22**: 206–312.
- Jovet-Ast, S. (1954): Le genre *Colura*. Hépatiques. Lejeuneaceae, Diplasiae (supplément). *Rev. Bryol. et Lichénol.* **77**: 1–22.
- Jovet-Ast, S. (1980): La section *Oidocorys* S. J.-A. du genre *Colura* Dum. est-elle âgée de plus de 100 millions d'années? *Cryptog., Bryol. Lichénol.* **1**: 277–287.
- Kornaś, J. (1981): Dysjunkcje transoceaniczne w nowym świetle. *Kosmos* **2**: 141–160.
- Löve, A. (1967): The evolutionary significance of disjunctions. *Taxon* **16**: 324–333.
- Manton, I., Vida, G. (1968): Cytology of the fern flora of Tristan da Cunha. *Proc. Roy. Soc. B.* **170**: 361–379.
- Meggers, B. J., Ayensu, E. S., Duckworth, W. D. (ed., 1973): *Tropical Forest Ecosystems in Africa and South America: a comparative review*. Smithsonian Institution, Washington, 350 pp.

- Mizutani, M. (1979): Mosses from Eastern Nepal collected by Himalayan Expedition of Chiba University in 1977. *J. Hattori Bot. Lab.* **46**: 289–310.
- Moore, H. jr. (1973): Palms in the tropical forest ecosystems of Africa and South America. In: Meggers, B. J. et al. 63–88.
- Ochyr, R., Pócs, T. (1983): East African Bryophytes, VI. Polish collections. *Acta Bot. Acad. Sci. Hung.* **28**: 361–389.
- Pócs, T. (1975): Affinities between the bryoflora of East Africa and Madagascar. *Boissiera* **24**: 125–128.
- Pócs, T. (1976a): Correlations between the tropical African and Asian bryofloras, I. *J. Hattori Bot. Lab.* **41**: 95–106.
- Pócs, T. (1976b): Bioclimatic studies in the Uluguru Mountains (Tanzania, East Africa). II. Correlations between orography, climate and vegetation. *Acta Bot. Acad. Sci. Hung.* **22**: 163–183.
- Pócs, T. (1978): Epiphyllous communities and their distribution in East Africa. *Bryophyt. Biblioth.* **13**: 681–713.
- Pócs, T. (1982a): Examples of the significance of historical factors in the composition of bryofloras. In: Geissler and Greene, *Beih. Nova Hedwigia* **71**: 305–311.
- Pócs, T. (1982b): Tropical forest bryophytes. In: A. J. E. Smith (ed.): *Bryophyte Ecology*. Chapman and Hall, London, 59–104.
- Pócs, T. (1984): Synopsis of the African Lepidozioideae K. Müll. In press.
- Prance, G. T. (1977): Floristic inventory of the tropics: where do we stand. *Ann. Missouri Bot. Gard.* **61**: 659–684.
- Proskauer, J. (1954): On *Sphaerocarpos stipitatus* and the genus *Sphaerocarpos*. *J. Linn. Soc. Bot.* **55**: 143–157.
- Reenen, G. B. A. van (1982): Studies on Colombian cryptogams, XII. High Andean species of *Herbertus* S. F. Gray (Hepaticae). *Lindbergia* **8**: 110–120.
- Renauld, F. (1897): *Prodrome de la flore bryologique de Madagascar, des Mascareignes et de Comores*. Monaco, 296 pp.
- Renauld, F., Cardot, J. (1915): *Les mousses de Madagascar*. In: Grandidier, A. et G. Histoire physique, naturelle et politique de Madagascar, vol. 39. Imprimerie Nationale, Paris, 562 pp.
- Reyes, D. M. (1982): El género *Diplasiolejeunea* en Cuba. *Acta Bot. Acad. Sci. Hung.* **28**: 145–180.
- Richards, P. W. (1973): Africa, the “Odd Man Out”. In: Meggers et al., 21–26.
- Schiffner, V. (1942): Monographie der Gattung *Exormotheca* Mitten. *Hedwigia* **81**: 40–74.
- Schmitt, V., Winkler, S. (1969): Systematische Untersuchungen über die foliose Lebermoosgattung *Stephaniella* Jack. *Österr. Bot. Zeitschr.* **115**: 120–135.
- Schofield, W. B. (1974): Bipolar disjunctive mosses in the Southern Hemisphere, with particular reference to New Zealand. *J. Hattori Bot. Lab.* **38**: 13–32.
- Schofield, W. B., Crum, H. A. (1972): Disjunctions in bryophytes. *Ann. Missouri Bot. Garden* **59**: 174–202.
- Schuster, R. M. (1962): North American Lejeuneaceae, VIII. *Lejeunea*, subgenera *Microlejeunea* and *Chaetolejeunea*. *J. Hattori Bot. Lab.* **25**: 1–80.
- Schuster, R. M. (1964): Studies on Hepaticae, XIX–XX. *Cephalozia* (Spr.) Schiffn. and *Andrewsianthus* Schust. *Nova Hedwigia* **8**: 201–209.
- Schuster, R. M. (1966): Studies in Lophoziaaceae. 1. The genera *Anastrophyllum* and *Sphenolobus* and their segregates. 2. *Cephalobus* gen. nov., *Acrolophozia* gen. nov. and *Protomarsupella* gen. nov. *Rev. Bryol. Lichénol.* **34**: 240–287.
- Schuster, R. M. (1967): A note on the genus *Gymnocolea* Dum. *Bryologist* **70**: 111–112.
- Schuster, R. M. (1969a): Problems of antipodal distribution in lower land plants. *Taxon* **18**: 46–90.
- Schuster, R. M. (1972): Continental movements, “Wallace’s line” and Indomalayan-Australasian dispersal of land plants: some eclectic concepts. *Bot. Review* **38**: 3–86.
- Schuster, R. M. (1973) “1971”: Studies on Cephaloziaaceae. *Nova Hedwigia* **22**: 121–265.
- Schuster, R. M. (1979): On the persistence and dispersal of transantarctic Hepaticae. *Canad. J. Bot.* **57**: 2119–2225.
- Schuster, R. M. (1966, 1969b, 1980): *The Hepaticae and Anthocerotae of North America East of the Hundredth Meridian I, II, IV*. Columbia Univ. Press, London, 802, 1062, 1334 pp.
- Schuster, R. M., Engel, J. (1977): Austral Hepaticae, V. The Schistochilaceae of South America. *J. Hattori Bot. Lab.* **42**: 273–423.
- Sjödin, Å. (1980): Index to Distribution Maps of Bryophytes 1887–1975, II. Hepaticae. *Växtekologiska studier* **12**: Almqvist and Wiksell, Stockholm, 143 pp.

- Sjögren, E. (1978): Bryophyte vegetation in the Azores Islands. *Mem. Soc. Broteriana* **26**: 1-283 + 7 t.
- Spruce, R. (1882): *On Cephalozia, its Subgenera and some Allied Genera*. Malton, 99 pp.
- Spruce, R. (1884-1885): Hepaticae amazonicae et andinae. (Hepaticae of the Amazon and of the Andes of Peru and Ecuador.) *Trans. Proc. Bot. Soc. (Edinburgh)* **15**: 1-590 + 22 t.
- Stearn, W. T. (1971): A survey of the tropical genera *Oplonia* and *Psilanthele* (Acanthaceae). *Bull. Brit. Mus. Hist. Nat.* **4**: 259-323.
- Steenis, C. G. G. J. van (1957): Specific and infraspecific delimitation. *Flora Malesiana* **I.5**. CLXVII. CCXXXIV.
- Stephani, F. (1898-1924): *Species Hepaticarum*, I: 1898-1900, 113 pp.; II: 1901-1905, 615 pp.; III: 1906-1909, 693 pp.; IV: 1909-1912, 824 pp.; V: 1912-1917, 1044 pp.; VI: 1917-1924, 763 pp.
- Stotler, R. E., Crandall-Stotler, B. (1974): A Monograph of the Genus *Bryopteris* (Swartz) Nees von Esenbeck. *Bryoph. Biblioth.* **3**: J. Cramer, Vaduz, 234 pp. + 32 t.
- Thorne, R. F. (1973): Floristic relationships between tropical Africa and tropical America. In: Meggers et al., 27-47.
- Tixier, P. (1979): Contribution à l'étude du genre *Cololejeunea*. Les *Cololejeunoidées* de Nouvelle Calédonie. Essai monographique. *Nova Hedwigia* **31**: 721-787.
- Tixier, P. (1980): Contribution à l'étude du genre *Cololejeunea* (Lejeuneaceae), IX. Espèces nouvelles du sous genre *Pedinolejeunea* (Ben.) Mizutani en région néotropicale. *Bradea, Rio de Janeiro* **3**: 35-44.
- Touw, A. (1982): Notes on the use of infraspecific categories by bryologists. In: Geissler and Greene, *Beih. Nova Hedwigia* **71**: 1-6.
- Troll, C. (1961): Klima und Pflanzenkleid der Erde in dreidimensionaler Sicht. *Naturwiss.* **48**: 332-348.
- Tryon, A. (1966): Origin of the fern flora of Tristan da Cunha. *Br. Fern Gaz.* **9**: 269-276.
- Udar, K., Awasthi, U. S. (1982): The genus *Schiffneriolejeunea* Verd. (Hepaticae) in India. *Lindbergia* **8**: 55-59.
- Váňa, J. (1974): Studien über die Jungermannioideae (Hepaticae) 4. Jungermannia Subg. *Plectocolea* und Subg. *Solenostoma*: Allgemeines, süd- und mittelamerikanische Arten. *Folia Geobot. Phytotax., Praha* **9**: 179-208.
- Váňa, J. (1980): Some new South and Central American Hepatics. *J. Hattori Bot. Lab.* **48**: 225-234.
- Váňa, J. (1982): Notes on some African Hepatic genera 1-5. *Folia Geobot. Phytotax., Praha* **17**: 63-87.
- Váňa, J., Pócs, T., De Sloover, J. L. (1979): Hépatiques d'Afrique tropicale. *Lejeunia n. ser.* **98**: 1-23.
- Vanden Berghen, C. (1972a): Hépatiques épiphylls récoltés au Burundi par J. Lewalle. *Bull. Jard. Bot. Nat. Belg.* **42**: 431-494.
- Vanden Berghen, C. (1972b): Hépatiques et Anthocérotes — Hepaticae and Anthocerotae. In: Symoens, J.-J. (ed.): Résult. scient. *Exploration Hydrobiologique du bassin Lac Bangweulu et Luapula*, **8**: 1-202.
- Vanden Berghen, C. (1978): Hépatiques du Shaba. Corrections et additions. *Bull. Jard. Bot. Nat. Belg.* **48**: 367-372.
- Yamada, K. (1979): A revision of Asian taxa of *Radula*, Hepaticae. *J. Hattori Bot. Lab.* **45**: 201-312.
- Zanten, B. O. van (1976): Preliminary report on germination experiments designed to estimate the survival chances of moss spores during aerial transoceanic long-range dispersal in the Southern Hemisphere, with particular reference of New Zealand. *J. Hattori Bot. Lab.* **41**: 133-140.
- Zanten, B. O. van (1978): Experimental studies on trans-oceanic long-range dispersal of moss spores in the Southern Hemisphere. *J. Hattori Bot. Lab.* **44**: 455-482.
- Zanten, B. O. van (1979): Experimenteel onderzoek over de mogelijkheden van lange-afstand-verspreiding van mossoren op het Zuidelijk Halfrond. *Vakblad Biologen* **59**: 358-363.
- Zanten, B. O. van, Pócs, T. (1981): Distribution and dispersal of Bryophytes. In: Schultze-Motel, W. (ed.): *Advances in Bryology* **1**: 479-562.

THE REDISCOVERY OF *LOISEAUBRYUM EPHEMEROIDES* BIZOT (MUSCI: FUNARIACEAE) IN NIGERIA

RYSZARD OCHYRA

BOTANICAL INSTITUTE, POLISH ACADEMY OF SCIENCES, KRAKÓW, POLAND

(Received: 15 June 1982)

Loiseaubryum ephemeroides Bizot, unreported since its original description from Chad, is recorded for the first time from the eastern Nigeria. In comparison with the type specimen the Nigerian plants are fully developed and have distinct elongate stems with spirally arranged leaves. BIZOT's hypothesis regarding a deciduous operculum in *Loiseaubryum* is confirmed. A more complete description and a new original drawing of the only species of this genus, *L. ephemeroides*, are provided, and affinities of *Loiseaubryum* are discussed. All African genera of the Funariaceae are distinguished in a key. An endemic African species, *Physcomitrella magdalenae* De Sloover, is transferred to the genus *Aphanorrhagma* Sull., and an appropriate new combination, *A. magdalenae* (De Sloover) Ochyra, is made.

While identifying a small collection of mosses from eastern Nigeria which was delivered to me by Prof. J. KORNAŚ of the Jagiellonian University of Kraków, Poland, my attention was called to two gatherings of an unusual funarioid moss in fine fruiting condition collected on wet mud along rivers. Gametophytically, it resembled *Micropoma niloticum* (Delile) Lindb., a species growing on similar habitats. However, it was completely different in structure of its sporophytes, especially in the shape of seta, operculum and calyptra. Inasmuch as this distinctive genus had not been reported by BROTHÉRUS (1924) in his world-wide treatment of the moss genera, I tentatively planned to describe the plants from Nigeria as a new species and genus because I had failed to find any similarities in descriptions with other species and genera of the Funariaceae. Luckily, at the same time I received "Enumeratio muscorum novarum II" by BIZOT (1976) where I found a description and an illustration of *Loiseaubryum ephemeroides*, a new species and genus of the Funariaceae discovered in the adjoining Chad. Both the detailed description and the excellent drawing agreed in several respects with Nigerian plants. I subsequently sent the Nigerian specimens to Prof. M. BIZOT of Dijon, France, who informed me that they do not differ materially from the type specimens of *L. ephemeroides* and the differences are mainly caused by the disparate growing stages of these plants. While describing *L. ephemeroides* M. BIZOT had only juvenile plants whereas those from Nigeria are mature ones. Therefore I found it necessary to make certain adjustments and emendations of the original diagnosis and to give a new illustration of *L. ephemeroides* on the basis of mature plants. A description of the Nigerian plants is given below.

***Loiseaubryum ephemeroides* Bizot, Revue Bryol. Lichénol., n. ser. 42 (3): 850 (1976) (Figs 1-12)**

Plants very small, bright green to green in color, gregarious or scattered amidst persistent protonemata, usually 1.5-2.5 mm, radiculose below, rhizoids smooth. Axis red, simple or usually repeatedly forked, in cross section showing weakly differentiated central strand of small, thicker-walled cells becoming larger and thinner-walled towards the periphery. Leaves

generally several to about ten, soft, lanceolate to linear-lanceolate, $0.3-0.5 \times 1.5-2.0$ mm, smaller and distant in the lower part of the stem becoming larger and more clustered above, irregularly shrunk when dry, erect to erect-spreading when moist. Perichetial leaves forming terminal rosette, linear-lanceolate, more or less acuminate, the apex tapering into a long, capillary point. Costa $40-45$ μm wide near the base ending at or below the base of the acumen in vegetative leaves, disappearing in the slender acumen in perichaetial leaves and thus appearing long excurrent. Margin plane, bluntly serrate to serrulate towards apex, entire near base. Leaf cells laxly oblong-hexagonal to rectangular, $40-50 \times 100-130$ μm , thin-walled, becoming more elongate and larger near the base, in the median portion tending to be narrower towards margin but not forming the distinct border. Antheridia not seen, perichaetia without paraphyses. Seta short, $1.5-2.0$ mm, light brown, arcuate. Capsule small, $0.5-0.7$ mm in diameter, ovoid becoming hemispheric, wide-mouthed and chestnut coloured with age. Exothecial cells very delicate, mostly quadrate to irregularly rounded-hexagonal, large, thin-walled, slightly collenchymatous, firm and oblate in 3-5 suboral rows, with stomata at the base. The stomata phaneroporous to slightly cryptoporous consisting of central pore in a circular guard cell. Annulus and peristome lacking, operculum plane. Calyptra very small, short-rostrate, cucullate, not inflated, slightly split into two not spreading lobes, smooth and naked, covering only the uppermost portion of the mature capsule. Spores brown, ellipsoidal or somewhat angled, $35-40$ μm , densely papillose-spinose, mature in dry season.

Specimens examined: (1) Nigeria, Borno State, Ngadda River just below Lake Alau (= Alo) near Maiduguri, $11^{\circ}43' \text{ N}$, $13^{\circ}18' \text{ E}$, elevation 320 m, dried-up river bed, shady place under *Mimosa pigra*, February 8, 1978, KORNAŠ 5 (KRA, KRAM, ALTA, B, BM, BR, C, CANM, COLO, GL, GRO, H, herb. Hoe, L, MO, NAM, NICH, NY, PC, S, U, UBC); (2) Nigeria, Borno State, Yedseram (Mbuli) River, 6 km S of Dikwa, $12^{\circ}01' \text{ N}$, $13^{\circ}53' \text{ E}$, elevation 300 m, dried-up river bed, gray clay, February 3, 1978, KORNAŠ 6 (KRA, KRAM, ALTA, B, BM, BR, C, CANM, COLO, EGR, GL, GRO, H, herb. Fife, Hoe, L, MO, NAM, NICH, NY, PC, S, U).

In comparison with the type specimen from Chad the Nigerian plants described above show a few differences which were best expressed by BIZOT who had also examined this material, and some of his comments (personal communication, May 14, 1979) follow:

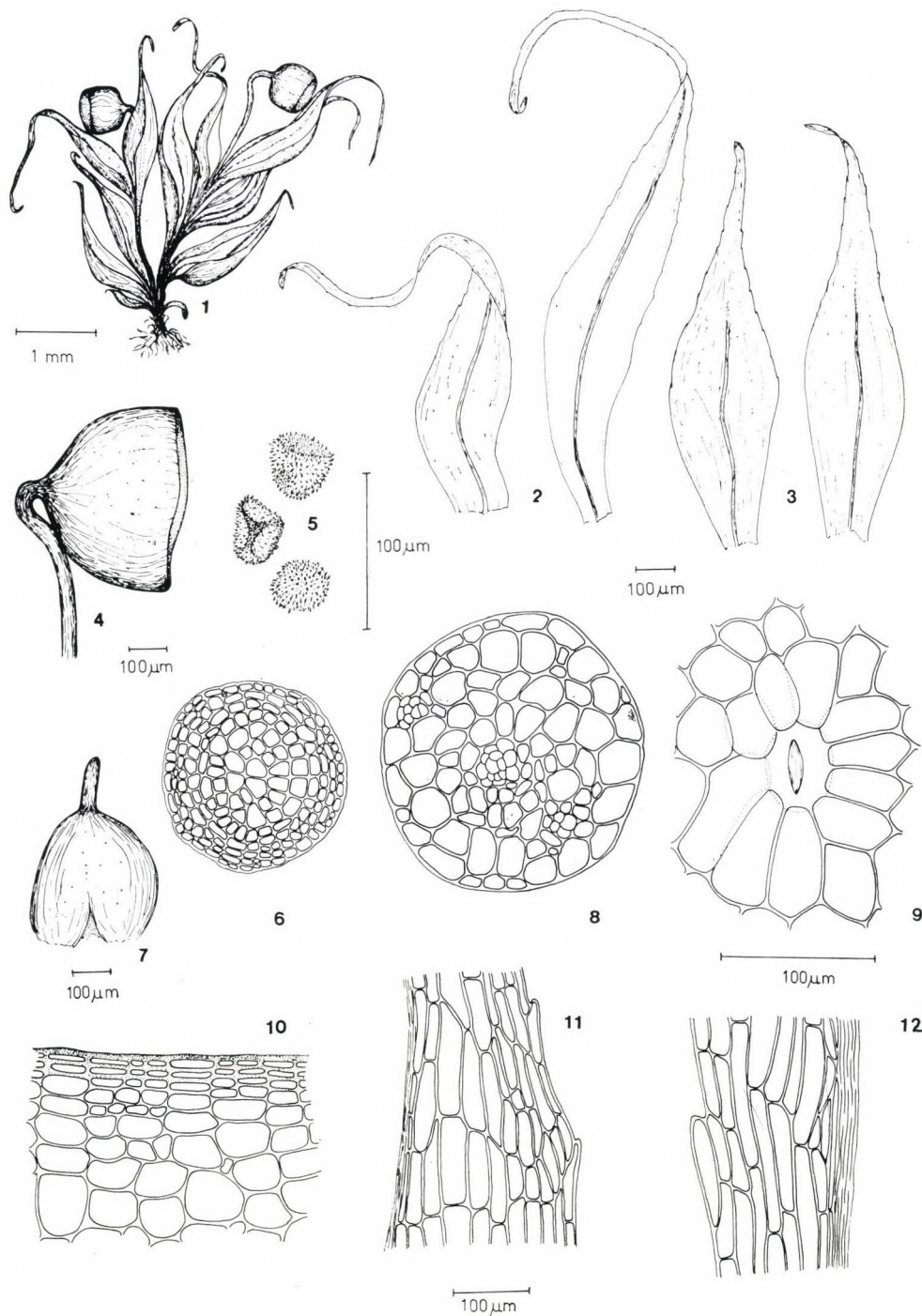
J'ai retrouvé *Loiseaubryum ephemeroides* en très bon état mais plus développé que le type, il est beaucoup plus grand et sa tige plus allongée et non "subnullus" les feuilles sont écartées sur le tige et non en rosette, c'est probablement la forme normale adulte tandis que j'ai décrit la forme jeune. Mon hypothèse "operculum . . . secedens?" est bien vérifiée.

Thus, the normal, mature plants of *L. ephemeroides* are not stemless but have elongate stems, $1.5-2.0$ mm high and spirally arranged leaves which are not crowded only in a rosette as it was stated in diagnosis.

There are only two other taxa of the Funariaceae for which *Loiseaubryum*

Plate I

Loiseaubryum ephemeroides. 1. Habit; 2. Perichaetial leaves; 3. Lower vegetative leaves; 4. Capsule, dry and empty; 5. Spores; 6. Operculum; 7. Calyptra; 8. Cross section of the lower part of stem; 9. Stoma; 10. Exothecial and suboral cells; 11. Cells above leaf shoulder; 12. Cells below leaf shoulder.



is likely to be mistaken. One of them is the African genus *Micropoma* Lindb. consisting of two species, *M. niloticum* (Delile) Lindb. in Broth. and *M. buko-bense* Broth., both growing on similar habitats and occurring in the eastern part of the continent from Lower Egypt to Zimbabwe. I have not seen the type specimens of both species. However, the illustrations available (BROTHERUS 1910, 1924, SIM 1926) and the descriptions provided by BROTHERUS (1910, 1924) and SIM (1926) clearly indicate that none of the sporophyte characteristics apply to *Loiseaubryum*.

Loiseaubryum looks like *Micropoma* and shares several characteristics with that genus especially in the structure of the gametophyte. The most obvious features of *Loiseaubryum* which separate it from *Micropoma* are the sporophyte and the persistent protonema. *Loiseaubryum* has an unusual aggregation of characteristics, a combination not known in *Micropoma* or in other Funariaceae: persistent protonema, emergent capsule on longer, arcuate seta, completely plane operculum without any apiculus and a short-beaked, cucullate, smooth calyptra which is slightly split into 2 lobes.

On the other hand, *Micropoma* has immersed capsule on very short, straight seta, apiculate operculum and long-beaked calyptra, which is inflated at the base, mitrate and becoming split into 3–4 widely spreading lobes.

Loiseaubryum shows also some similarities with the species of *Physcomitrium* subgenus *Cryptopyxis* (C. Muell.) Broth. which, however, are not known from continental Africa. On the other hand, exact relationships between the latter taxon and *Micropoma* are subject to question, and my view is, that there are insufficient reasons to regard them as separate taxa. *Micropoma* and subgenus *Cryptopyxis* of *Physcomitrium* may be distinguished only by polygamous and autoicous inflorescence, respectively, and I am strongly inclined to unite them in one genus. A study of greater geographical scope will doubtless result in radical modification of the present concept of some genera of the Funariaceae.

Quite recently FIFE and MAGILL (1982) while discussing the affinities of a newly described South African genus and species *Cygnicollum immersum* suggest that *Loiseaubryum* should be best placed in the Ephemeraceae because of the fact that it has firm-walled and elongate leaf cells, two-celled stomata, and the gametophyte arising from a persistent protonema. I examined numerous stomata in the Nigerian plants of *Loiseaubryum* and found them to be evidently unicellular, and this fits well the circumscription of the Funariaceae (BROTHERUS 1924). It seems to me that the persistent protonema is somewhat overvaluated as a diagnostic character in the Funariales mostly owing to the short life cycle of the most funarioid mosses. In mature plants of *Loiseaubryum* the protonema is rather disappearing and seems to be physiologically inactive. Thus, my view is that the best placement of *Loiseaubryum* is in the Funariaceae as originally BIZOT (1976) thought.

The localities where *L. ephemeroides* has been found so far are all adjacent to Lake Chad. The species has probably been collected on so few occasions because of its inconspicuous size and short life cycle. However, further records are to be expected as more areas are explored, and I urge collectors in northern part of tropical Africa, especially in Sudanian and Sahelian zones, to watch for it.

Like all the other Funariaceae *L. ephemeroides* has a short life cycle and is therefore a successful pioneer of ephemeral situations. It thrives on mud soil and on silt, on banks of rivers, creeks, ditches, or ponds as well as on bottoms of dried-up reservoirs. Most frequent associates seem to be species of *Riccia*. The Nigerian plants are intermixed with *Riccia membranacea* Mont. (det. T. Pócs), and Bizot (1976) also reported *L. ephemeroides* growing together with a *Riccia* sp.

BROTHERUS (1924) in his world-wide treatment of genera of mosses recognized nine genera in the Funariaceae. However, since the publication of that work five new genera have been added to this family. Three of them were described from Africa: *Jonesiobryum* Bizot, Pierrot & Pócs ex Bizot & Pócs (Bizot et al. 1974; Bizot, Pócs 1974), *Loiseaubryum* Bizot from Chad (Bizot 1976), and recently *Cygnicollum* Fife & Magill from the Cape of Good Hope, South Africa (Fife, Magill 1982). On the other hand Fife (1980) on the basis of detailed study transferred two American genera, *Costesia* Thér. and *Neosharpiella* Robins. & Delg. from the Funariaceae to the Gigaspermaceae.

Moreover, the representatives of two other genera have also been added to the moss flora of the continental Africa: *Pyramidula algeriensis* Chudeau & Douin from Algeria (Douin 1904) and *Physcomitrella magdalenae* De Sloover described from Rwanda (De Sloover 1975). Although *Physcomitrella* has been generally accepted as an independent genus by many bryologists, I have decided to follow the usage of European bryologists (Corley et al. 1981) and to include it in *Aphanorrhegma* Sull. It does not merit recognition at the genus level because of the only cleistocarpous capsules whereas in *Aphanorrhegma* capsules dehiscce irregularly. Similar forms can be found in other genera of mosses, e.g. in *Pottia* where *P. bryoides* is characterized by cleistocarpous capsules, and all the other species have normally operculate capsules. Two interesting instances of cleistocarpous species in normally stegocarpous genera are extensively discussed by Herzog (1915): one in the Ditrichaceae (*Tristichium lorentzii* C. Muell.) and one in the Bartramiaceae (*Conostomum cleistocarpum* Herz.). In consequence the following new combination is proposed:

Aphanorrhagma magdalenae (De Sloover) Ochyra, **comb. nov.**

Basionym: *Physcomitrella magdalenae* De Sloover, Bull. Jard. Bot. Nat. Belg. 45: 131. 1–22 (1975)

At present from the African continent eleven genera of the Funariaceae are known of which six are endemic. They may be distinguished in the following key:

- 1 Capsule cleistocarpous 2
- 2 Capsule with a strongly cygneous neck *Cygnicollum*
- 2 Capsule globose without a distinct neck 3
- 3 Calyptra large, enclosing the entire capsule *Physcomitrellopsis*
- 3 Calyptra very small, conic-mitrate covering only the beak and the uppermost part of the mature capsule *Aphanorrhagma*
- 1 Capsule with a deciduous lid 4
- 4 Capsule nearly or long-exserted 5
- 5 Calyptra 4-angled investing the entire capsule and clasping the seta *Pyramidula*
- 5 Calyptra neither angled nor sheathing the entire capsule 6
- 6 Capsules peristomate, strongly inclined and very asymmetric *Funaria*
- 6 Capsules erect and symmetric 7
- 7 Peristome none, annulus present, calyptra cucullate, capsules broadly pyriform or urceolate *Physcomitrium*
- 7 Peristome usually present, rarely rudimentary or none, annulus none, capsules subcylindric to narrowly pyriform *Entosthodon*
- 4 Capsules immersed 8
- 8 Annulus present *Jonesiobryum*
- 8 Annulus none 9
- 9 Calyptra 8-ribbed *Goniomitrium*
- 9 Calyptra smooth 10
- 10 Seta arcuate, operculum plane, calyptra cucullate, short-beaked ... *Loiseaubryum*
- 10 Seta straight, very short, operculum apiculate, calyptra inflated-mitrate, long-beaked, split into 3–4 widely spreading lobes *Micropoma* (+ *Physcomitrium* subg. *Cryptopyxis*)

ACKNOWLEDGEMENTS

My most sincere thanks are due to Prof. J. KORNÁŠ for providing me the collections of the Nigerian mosses for examination. I am deeply grateful to the late Prof. M. BIZOT, whose sudden death in November 1979 was a terrible shock to African bryology, for comparison the Nigerian specimens of *L. ephemeroïdes* with the type and invaluable informations. I also thank T. PÓCS and G. KIS for the suggestions and criticism of the manuscript, and B. TARNOŃSKA, who drew the illustration.

REFERENCES

- Bizot, M. (1976): Enumeratio muscorum novarum, II. *Rev. Bryol. Lichénol.* **42**: 843–855.
 Bizot, M., Pócs, T. (1974): East African bryophytes, I. *Act. Acad. Paedag. Agr., n. ser.* **12**: 383–449.
 Bizot, M., Pierrot, R. B., Pócs, T. (1974): Trois genres nouveaux de muscinées. *Rev. Bryol. Lichénol.* **40**: 25–31.
 Brotherus, V. F. (1910): Musci, in: J. Mildbraed: *Wissenschaftliche Ergebnisse der Deutschen Zentral-Afrika Expedition 1907–1908*, **2**: 136–176. Leipzig.

- Brotherus, V. F. (1924): Funariaceae, in: Engler, A. & Prantl, K., *Die Natürlichen Pflanzenfamilien*, Ed. 2, **10**: 320–332. Leipzig.
- Corley, M. F. V., Crundwell, A. C., Düll, R., Hill, M. O., Smith, A. J. E. (1981): Mosses of Europe and the Azores; an annotated list of species, with synonyms from the recent literature. *J. Bryol.* **11**: 609–689.
- De Sloover, J. L. (1975): Note de bryologie africaine, III. *Physcomitrella magdalenae* sp. nov. *Bull. Jard. Bot. Nat. Belg.* **45**: 131–135.
- Douin, C. (1904): *Pyramidula algeriensis* R. Chudeau & Douin sp. nov. Chartres, Imprimerie Durand.
- Fife, A. J. (1980): The affinities of *Costesia* and *Neosharpiella* and notes on the Gigaspermaceae (Musci). *The Bryologist* **83**: 466–476.
- Fife, A. J., Magill, R. E. (1982): *Cygnicollum immersum*, a new genus and species of Funariaceae from the Cape of Good Hope. *The Bryologist* **85**: 99–103.
- Herzog, Th. (1915): Zwei kleistokarpe Moose der bolivianischen Hochcordillere. *Flora* **107**: 317–326.
- Sim, T. R. (1926): The Bryophyta of South Africa, comprising Sphaerocarpaceae, Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Andreaeales, Polytrichales, Bryales. *Trans. R. Soc. S. Afr.* **15**: 1–475.

NEW NAMES AND NEW SPECIES IN THE FLORA OF CUBA AND ANTILLES, III

A. BORHIDI

RESEARCH INSTITUTE FOR BOTANY, HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT, HUNGARY

(Received: 1 September 1982)

A list of necessary nomenclatural changes in the flora of the Greater Antilles, principally that of Cuba, are reported with respect to the neotropical flora, namely 43 new status and combinations, 2 new names and 35 new taxa including 23 species.

New taxa are: Euphorbiaceae: *Platygyne dentata* f. *subglabra*, *Chaetocarpus globosus* f. *puberula*, *Ch. oblongatus* var. *subenervis* and var. *monticola*, *Ch. parvifolius*, all from Cuba; Rubiaceae: *Rondeletia crassinervis*, *R. feketiana*, *R. filisepala*, *R. liogieri* and *R. exasperata*, *Antirhea ekmanii* and *A. radiata* ssp. *haitiensis*, *Machaonia leonardorum* and *Scolosanthus liogieri*, all from Hispaniola, *Scolosanthus portoricensis* from Puerto Rico, *Scolosanthus howardi* and *S. multiflorus* ssp. *hirticalyx* from Jamaica, finally *Phialanthus glaberrimus*, *Ph. guantanamoensis*, *Ph. inflatus*, *Ph. macrocalyx*, *Ph. ca. marianus*, *Ph. acunae*, *Scolosanthus acunae*, *S. crucifer* var. *acutus*, var. *microphyllus*, var. *subtomentosus*, *S. hirsutus*, *S. hispidus*, *S. moanus*, *S. nannophyllus*, *S. pycnophyllus* and *S. reticulatus* from Cuba; Compositae: *Lachnorrhiza piloselloides* ssp. *stenophylla*, ssp. *micrantha* and var. *dubia*, all from Cuba.

New names are: *Eugenia rosariensis* and *Miconia javorkaeana* both for Cuban plants.

New combinations and status are: Euphorbiaceae: *Acidocroton trichophyllus* ssp. *pilosulus*, *Bonania cubana* ssp. *acunae* and ssp. *microphylla*, *B. elliptica* var. *spinosa*, *B. emarginata* ssp. *suborbiculata* and ssp. *nipensis*, *Chaetocarpus globosus* var. *lepidotus*; Icacinaceae: *Mappia racemosa* ssp. *brachycarpa*, Rhamnaceae: *Karwinskia potrerilloana*; Myrtaceae: *Plinia acutissima* var. *cidrensis*, *Hottia goavensis* var. *micrantha*, *Myrcia polyneura*, *Myrtus tiburona*. Melastomataceae: *Tetrazygiopsis ancistrophora*, *T. cordata*, *T. longicollis*, *T. stahlii*, *T. urbanii*, *Pachyanthus cubensis* ssp. *blancheanus*, *Calycogonium grisebachii* var. *cristalense*, *C. heterophyllum* ssp. *maculatum*; Ericaceae: *Lyonia truncata* ssp. *montecristina*, *L. rubiginosa* ssp. *costata* and ssp. *stahlii*, *L. nipensis* ssp. *depressinerva*, *L. latifolia* ssp. *calycosa*, *L. glandulosa* ssp. *revolutifolia*; Gesneriaceae: *Dalbergaria cubensis*, Acanthaceae: *Justicia calcicola* var. *maestrensis*, *Apassalus diffusus* var. *glabratus*; Rubiaceae: *Antirhea acutata* ssp. *elliptica*, *Ottoschmidtia microphylla* ssp. *haitiensis*, *Hedyotis maestrensis*, *H. polyphylla*, *Spermacoce matanzasia*; Compositae: *Koanophyllon turquinense*, *K. villosum* ssp. *cubense*, ssp. *cynanchifolium* and ssp. *lindenianum*; *Isocarpha atriplicifolia* ssp. *billbergiana* and ssp. *wrightii*, *I. oppositifolia* var. *glabrata* and ssp. *achyranthes*. Short discussion on taxonomic categories and a survey of Cuban Eupatorieae according to the new taxonomic concept is also presented.

Introduction

In 1981, I had an opportunity for revising some important specimens of the Herbarium of the Natural History Museum in Paris (P) and a number of type collections of the Regnell Herbarium in Stockholm (S). These studies enabled me to solve some taxonomic problems on the flora of Cuba, Hispaniola and the West Indies. My interest turned — first of all — to the families of Rubiaceae, Melastomataceae, Euphorbiaceae and Myrtaceae.

I compiled also the data of the most important taxonomic studies and monographs dealing with the flora of Cuba as a supplementary contribution to it and a guide for botanists

working on or with Cuban plants for using up-to-date terms and names. In this I did not want to adapt automatically the results of the studied taxonomic works, but to collate them with my personal experience and to make corrections or critical notes, if necessary.

Taxonomic ranks

As I pointed out in the first article of this series (Acta Bot. Acad. Sci. Hung. 25: 31–32, 1979) taxonomic ranks are used in very different sense by taxonomists. A lot of excellent monographs based on technically perfect, up-to-date, multifarious investigations, using numerical and/or cladistic methods, etc. have their weak points concerning the consistent or inconsistent use of the taxonomic principles of ranking.

In my concept the criteria of the specific and infraspecific ranks are as follows:

Species: The populations of a species must be characterized by having one or more qualitative features different from those of the nearest species. It is favourable, when the different feature(s) are in the sexual organs, but it is not necessary. Vegetative features can be just as distinctive as the sexual ones. The limitation of the species must be based on the discontinuity of the natural variability ranges of the populations. The morphological break is essential in the separation of the species. This break is sometimes bridged by hybridogenous “intermediate” populations in the introgressional zones.

Subspecies: It is an infraspecific taxon characterized by chiefly quantitative morphological differences and represented by allopatric populations of an independent geographic or ecological distribution (e.g. altitudinal, geological substrate, etc.), without a sharp morphological separation from the typical taxon and with intermediate forms in the transitional zones. Vicariance at infraspecific level is essentially a characteristic of the subspecies and not of the variety.

Variety: It is represented by morphologically different but not separated populations distributed within the area of the typical taxon, without any characteristic geographic or ecologic pattern. Variety is the proper rank also for describing the intermediate populations of the overlapping subspecies, because “intermediate” is not a systematic taxon.

According to the above criteria a revaluation of the published taxa is suggested.

Lauraceae

According to LUNDELL [Wrightia 4: 99 (1969)] the Cuban species of the genus *Licaria* belong to the genus *Misanteca*, and their valid names are the following:

1. *Misanteca cubensis* (O. C. Schmidt) Lundell = *Nobeliodendron cubense* O. C. Schmidt; *Licaria cubensis* (O. C. Schmidt) Kostermans.
2. *Misanteca triandra* (Sw.) Mez = *Laurus triandrus* Sw. — *Acroclidium jamaicense* Nees — *Licaria jamaicensis* (Nees) Kostermans — *Misanteca jamaicensis* (Nees) Lundell.

Erythroxylaceae

3. *Erythroxylum echinodendron* Ekman = ***E. minutifolium* Griseb.** The type specimen of EKMAN seems to be nothing else than an extremely old and monstrous individual of *E. minutifolium* Griseb. widely distributed over the serpentine thickets of Cuba, including the type locality of the EKMAN's plant.

Polygalaceae

According to a revision made by GILLIS [Phytologia 32: 38 (1975)] the following changes are suggested:

4. ***Polygala penaea* L. ssp. *guantanamana* (Blake) Gillis = *Polygala guantanamana* Blake**
 5. ***Polygala penaea* L. ssp. *oblongata* (Britt.) Gillis = *Badiera oblongata* Britt. — *Polygala oblongata* (Britt.) Blake**

Euphorbiaceae

6. ***Acidocroton acunae* Borhidi et Muñiz. Acta Bot. Acad. Sci. Hung. 22: 305 (1976)** has been collected by E. L. EKMAN 16834 at the type locality.
 7. ***Acidocroton trichophyllus* Urb. ssp. *pilosulus* (Urb.) Borhidi **comb. et status novus.** *Acidocroton pilosulus* Urb. Feddes Repert. 28: 227 (1930)** is a montane vicariant subspecies closely related to *A. trichophyllus* Urb.

***Bonania* A. Rich. in Cuba**

On a comparative study of the type collections and a more extensive material of this genus, the author concluded that it is necessary to reduce the earlier described 8 Cuban species to 4, as follows:

8. ***Bonania cubana* A. Rich. in Sagra: Hist. Nat. Fis. Pol. Cuba 11: 201 (1850) tab. 68.**
 — **ssp. *cubana***
 — **ssp. *acunae* (Borhidi) Borhidi **stat. nov.****
 Basionymon: *Bonania acunae* Borhidi in Borhidi et Muñiz. Acta Bot. Acad. Sci. Hung. 22: 306 (1976).
 — **ssp. *microphylla* (Urb.) Borhidi **stat. nov.****
 Basionymon: *Bonania microphylla* Urb. Symb. Ant. 3: 311 (1902)
 9. ***Bonania elliptica* Urb. Symb. Ant. 9: 211 (1924)**
 — **var. *elliptica***
 — **var. *spinosa* (Urb.) Borhidi **stat. nov.****
 Basionymon: *Bonania spinosa* Urb. Sym. Ant. 9: 215 (1924).
 10. ***Bonania emarginata* Wr. in Griseb. Diagnoses 178 (1862).**
 — **ssp. *emarginata***
 — **ssp. *suborbiculata* (Borhidi et Urbino) Borhidi **stat. nov.****
 Basionymon: *Bonania suborbiculata* Borhidi et Urbino in Borhidi et Muñiz. Acta Bot. Acad. Sci. Hung. 22: 305 (1976).
 — **ssp. *nipensis* (Urb. et Ekm.) Borhidi **stat. nov.****
 Basionymon: *Bonania nipensis* Urb. et Ekm. in Urb. Feddes Repert. 28: 231 (1930).

11. *Bonania myricifolia* (Griseb.) Benth. et Hook.

12. *Platygyne dentata* Alain f. *subglabra* Borhidi f. *nova*

A typo differt foliis linearibus acute et remote dentatis utrinque glabris, pilis parcissimis suffultis. Holotypus: EKMAN 5048. Cuba; Oriente, Sierra Maestra, Pinal del Corajo, Nagua, 22. 3. 1915 (S).

13. *Ditta maestrensis* Borhidi in Borhidi, Imchanitskaya et Muñiz. Acta Agronom. Acad. Sci. Hung. 27: 433 (1978) occurs also in Hispaniola. The following collections of E. L. EKMAN represent this species: EKMAN H 6330; Santo Domingo, Cordillera Central, Prov. Azua, Loma Nalga de Maco on the ridge towards Pena Blanca. — H 12802. Santo Domingo, Cordillera Central, Prov. Monte Cristi, Monción high ridge between Rio Cenobi and Rio San Juan, alt.: 1900 m.

Chaetocarpus Thwait. in the Antilles

14. *Chaetocarpus globosus* (Sw.) Fawc. et Rendle var. *lepidotus* (Urb.) Borhidi **comb. et stat. nov.** — Basionymon: *Mettenia lepidota* Urb. Feddes Repert. 28: 230 (1930). It occurs in Jamaica (Blue Mountains, Port Royal, WEBSTER and WILSON 4935) W-Cuba (Sierra del Rosario, Rio Taco-Taco, EKMAN 17631) common in E-Cuba, and rare in Hispaniola (Santo Domingo; Cordillera Central, prov. Monte Cristi, Monción at Tomás, 24. 6. 1929. Ekman H 13016. The genus is new to Hispaniola. — f. *puberula* Borhidi f. *nova*

Foliis utrinque adpresse pilosis: Holotypus: EKMAN 15193 Cuba, Oriente, Sierra de Nipe, Loma Mensura at the very top, *Arthrotylidium* thicket. 22. 9. 1922 (S).

15. *Chaetocarpus oblongatus* (Alain) Borhidi

var. *subenervis* Borhidi var. *nova*

A typo differt: foliis oblongo ellipticis, rigide coriaceis, 2–5 cm longis, 7–15 mm latis, nervis lateralibus supra tenuissime impressis, subtus obsolete prominulis vel tenuissime impressis, plerumque vix conspicuis, inflorescentiis ferrugineo-pubescentibus.

Holotypus: BUCHER 106, Cuba; Oriente, Moa, 1939. HAC! Specim. examinata: ACUÑA 13150, Cuba; Oriente; Pinares de la Playa Vaca, Moa. 4. Nov. 1945. HAC!

— var. *monticola* Borhidi var. *nova*

A typo differt: ramulis glaberrimis, foliis 4–8 cm longis et 2–3,5 cm latis, utrinque, plerumque subtus reticulato-venosis et sparse prominenter punctatis.

Holotypus: ALAIN 3448 HAC; Cuba; Oriente; Charrascos de la Sierra de Moa, in alt. approx. 750–800 m.s.m. 25–26. Jul. 1953.

16. *Chaetocarpus parvifolius* Borhidi sp. *nova*

Frutex. Rami hornotini pilis erectis albis vel ferrugineis sparse strigillosi, veteriores teretes, glabri, cinerei, leviter striati, satis dense foliosi, internodiis 3–10 mm longis. Folia 1–2 mm longe petiolata, stipulis obovatibus, petiolis aequilongis (1–2 mm longis)

suffulta, oblongo-ovata vel lanceolata, basi obtusa vel rotundata, apice sensim attenuata et acuta, rariter levissime acuminata 1–2,5 cm longa et 4–10 mm lata, nervo medio supra in sulco bene prominente, lateralibus utroque latere 3–4 supra prominulis et postremo anguste impressis, subtus obsoletis vel inconspicuis, lamina supra viridis, nitida in sicco brunnea utrinque e basi tuberculato strigillosa, mox muricata et glabrescens, postremo glabra et impresso punctata, subtus in nervo medio persistenter strigillosa, margine integra vel minutissime et irregulariter crenulata, plana vel tenuiter recurva, chartacea vel subcoriacea. Cetera ignota.

Holotypus: ALAIN 3406; Cuba; Oriente, Sierra de Moa, dirección de Piedra La Vela, alt. approx. 700 m.s.m. 25–27. Jul. 1953. SV; isotypus: SV.

Obs.: *M. acutifoliae* Britt. et Wils. affinis, quae a specie nostra foliis multo majoribus, 2–11 cm longis, apice acuminatis, utrinque, praecipue subtus persistenter hirsutis, non tuberculato-strigillosis et postremo epunctatis clare differt.

Celastraceae

Tricerna Lieb.

The genus *Tricerna* Lieb. has been revalidated by LUNDELL and separated from the genus *Maytenus*. From the Cuban *Maytenus* species one belongs to this genus:

17. *Tricerna phyllanthoides* (Benth.) Lundell = *Maytenus phyllanthoides* Benth.

Icacinaceae

18. *Mappia racemosa* Jacq. ssp. *brachycarpa* (Griseb.) Borhidi **stat. nov.** — Basionymon: *Mappia racemosa* var. *brachycarpa* Griseb. Pl. Wright. I. Mem. Acad. Amer. Sci. Art. N. S. 8: 191 (1860) endemic to Cuba and Hispaniola.

Sapindaceae

19. *Thouinia canescens* Radlk. is an endemic of the W-Cuban limestone cliffs, based on the type specimen. It grows in the Pinar del Rio province, Sierra de los Organos, Sierra de Guane, Sierra de la Güira, and Sierra del Rosario, as a typical deciduous dwarf tree of the dry deciduous limestone shrub-forest of the mogotes. It does not live in Oriente as it is indicated in the Flora of Cuba 3: 195 (1953). The populations reported from E-Oriente under this name, belong to the *Thouinia hypoleuca* Borhidi Acta Bot. Acad. Sci. Hung. 22: 309 (1976).
20. *Thouinia baracoensis* Borhidi l.c. is not else, than an extreme form of *Thouinia cubensis* Radlk. according to LIPPOLD (in litt.).

Rhamnaceae

21. *Karwinskia potrerilloana* (Borhidi et Muñiz) Borhidi **comb. nova.** — Basionymon: *Rhamnidium potrerilloanum* Borhidi et Muñiz. Acta Bot. Acad. Sci. Hung. 18: 37 (1973). More recently collected flowering specimens showed that the ovary cells are 2-ovulated, characteristic for *Karwinskia*.

Myrtaceae

22. *Psidium nummularia* (Berg) Wr. in Sauv. = *Psidium acunae* Borhidi. Acta Bot. Acad. Sci. Hung. 17: 17 (1971). Syn. nov.

23. *Psidium tomasianum* Urb. et Ekm. Symb. Ant. 9: 465 (1928) is a valid species. The type specimen (EKMAN 18025 S!) is quite different from the specimens of *P. scopulorum* Ekm. et Urb. I could not find sufficient morphological evidence to unite the two species, as it was suggested by LEÓN and ALAIN in the Flora of Cuba 3: 416 (1953).
24. *Plinia acutissima* Urb. var. *cidrensis* (Urb.) Borhidi **stat. nov.** — Basionymon: *Plinia cidrensis* Urb. Ark. Bot. 22A 10: 27 (1926). Type: EKMAN H 6366 S!
25. *Hottea goavensis* Urb. var. *micrantha* (Urb. et Ekm.) Borhidi **stat. nov.** — Basionymon: *Hottea micrantha* Urb. et Ekm. Ark. Bot. 24A 4: 30 (1930).
26. *Calyptranthes gracilipes* Wr. in Sauv. = *C. arenicola* Urb. Syn. nov.
27. *Calyptranthes ermitensis* Borhidi Bot. Közlem. 64: 15 (1977) = *Calyptranthes mirabilis* Bisse et Rodriguez. Rev. Jard. Bot. Nac. Habana 1/2-3: 42 (1981). Syn. nov.
Calyptranthes mirabilis Bisse et Rodriguez is doubtless an illegitimate species, because it includes the type specimen of the earlier described *C. ermitensis* Borhidi (Alain 7268 HAC). It is regrettable that J. BISSE missed revising the abundant *Calyptranthes* collections of the Herbarium of the Cuban Academy of Sciences (HAC) in Santiago de las Vegas, which contains the holotype specimens of 16 *Calyptranthes* taxa described by BORHIDI and MUÑOZ, and did not use more up-to-date Myrtaceae-literature than volume 5 of the Symbolae Antillanae and the volume 3 of the Flora of Cuba.
28. *Myrcia polyneura* (Urb.) Borhidi **comb. nova**
 Basionymon: *Calyptranthes polyneura* Urb. Symb. Ant. 9: 94 (1923). Type: EKMAN 9055 (S!). The nervation, epidermis-type, and glandular pattern of the leaf blades are obviously similar to those of the species *Myrcia retivenia* Urb., *M. spinifolia* Borhidi et Acuña and *M. acunae* Borhidi.
29. *Myrtus cabanasensis* Britt. et Wils. = *Eugenia amblyophylla* Urb. Symb. Ant. 9: 511 (1928). Syn. nov.
30. *Myrtus tiburona* (Urb. et Ekm.) Borhidi **comb. nova**
 Basionymon: *Eugenia tiburona* Urb. et Ekm. Ark. Bot. 24A 4: 26 (1932).
31. *Myrtus tussacki* (Urb. et Ekm.) Burret = *Eugenia tussacki* Urb. et Ekm. Ark. Bot. 21A 5: 37 (1927); *Myrtus Barkeri* Urb. et Ekm. in schaed.
32. *Eugenia confusa* DC. = *Eugenia sooana* Borhidi. Acta Bot. Acad. Sci. Hung. 19: 37 (1973). Syn. nov.
33. *Eugenia cowellii* Britt. et Wils. = *Eugenia anthacanthoides* Ekm. et Urb. Symb. Ant. 9: 486 (1928) from Cabo Cruz, EKMAN 16177 S!, Syn. nov. and *Eugenia cahosiana* Urb. et Ekm. Ark. Bot. 21A 5: 28 (1927) from Haiti. Syn. nov.
34. *Eugenia lindahlui* Urb. et Ekm. Ark. Bot. 21A 5: 28 (1927) = *Eugenia orthioneura* Urb. l.c. 29. Syn. nov.
35. *Eugenia melanadenia* Kr. et Urb. is not endemic to Cuba, because it occurs also in Hispaniola: EKMAN H 16080 S! Santo Domingo, Cordillera Septentrional, Prov. de Santiago, Las Lagunas, hills at Arroyo Harenquillo, 400 m. 20. 10. 1930.
36. *Eugenia picardae* Kr. et Urb. Bot. Jahrb. 19: 608 (1895) = *Eugenia formonica* Urb. et Ekm. Ark. Bot. 22A 10: 36 (1929). Syn. nov. and *Eugenia pitoniana* Urb. et Ekm. l.c. 5: 30 (1927). Syn. nov.

37. *Eugenia piedraensis* Urb. = *Eugenia leonis* Borhidi. Acta Bot. Acad. Sci. Hung. 19: 39 (1973). Syn. nov.
38. *Eugenia rosariensis* Borhidi **nomen novum** = *Eugenia bakeri* Britt. et Wils. Mem. Torr. Bot. Cl. 16: 91 (1920); non *Eugenia bakeri* Elmer Leaflets Philipp. Bot. 7: 2355 (1914).
39. *Eugenia squarrosa* Urb. et Ekm. is not identical with *E. anthacanthoides* Ekm. et Urb. as it is treated in the Flora of Cuba 3: 463 (1953) by LEÓN and ALAIN. It is a valid species characterized by having minute coriaceous leaves with scarce impressed black glands above, slightly prominent ones beneath, and solitary, sessile glabrous flowers. It is a local endemic growing in the extremely dry thorn thickets of serpentine soils near Santa Clara. Type: EKMAN 18829 (S!), isotype: UPS!

Melastomataceae

40. *Miconia javorkaeana* Borhidi **nomen novum** = *Graffenrieda cordifolia* Alain Contr. Ocas. Mus. Hist. Nat. Col. La Salle 14: 1 (1955); *Miconia cordifolia* (Alain) Borhidi. Abstracta Bot. Univ. Budapest 5: 32 (1977) non *Miconia cordifolia* Wurdack. Phytologia 31 (6): 498 (1975).

Tetrazygiopsis Borhidi

Examinations carried out on larger materials collected on the Antilles made it necessary to transfer some further species of *Tetrazygia* — having long outer sepal lobes — into *Tetrazygiopsis*:

41. *Tetrazygiopsis ancistrophora* (Wr. in Sauv.) Borhidi **comb. nova**
Basionymon: *Tetrazygia ancistrophora* Wr. in Sauv. Anal. Acad. Cien. Habana 5: 465 (1868); syn.: *Miconia ancistrophora* Triana, Trans. Linn. Soc. 28: 103 (1871). — Cuba.
42. *Tetrazygiopsis cordata* (Alain) Borhidi **comb. nova**
Basionymon: *Tetrazygia cordata* Alain Brittonia 20: 158 (1978). — Hispaniola
43. *Tetrazygiopsis longicollis* (Urb. et Cogn.) Borhidi **comb. nova**
Basionymon: *Tetrazygia longicollis* Urb. et Cogn. Symb. Ant. 7: 310 (1913). — Hispaniola.
44. *Tetrazygiopsis stahlIIi* (Cogn.) Borhidi **comb. nova**
Basionymon: *Tetrazygia stahlIIi* Cogn. Jahrb. Bot. Gart. Mus. Berlin 4: 279 (1886). — Porto Rico.
45. *Tetrazygiopsis urbanIIi* (Cogn.) Borhidi **comb. nova**
Basionymon: *Tetrazygia urbanIIi* Cogn. Jahrb. Bot. Gart. Mus. Berlin 4: 278 (1886). — Porto Rico.

These studies indicate, that *Tetrazygiopsis* is a widely distributed endemic genus of the Antilles containing 13 species.

46. ***Pachyanthus cubensis*** A. Rich. ssp. ***blancheanus*** (Urb.) Borhidi **comb. stat. nova.** — Basionymon: *Miconia blanchiana* Urb. Feddes Repert. 17: 405 (1921). Syn.: *Pachyanthus blanchianus* Urb. et Ekm. Ark. Bot. 21A No. 5 : 44 (1927). — This plant of Hispaniola is a closely related taxon to *P. cubensis* A. Rich. There are only quantitative differences between the two taxa. For this reason it is necessary to classify it as a Hispaniolan subspecies of the Cuban taxon.
47. ***Calycogonium grisebachii*** Triana var. ***cristalense*** (Urb.) Borhidi **stat. nov.** — Basionymon: *Calycogonium cristalense* Urb. Feddes Repert. 22: 229 (1926). Typus: EKMAN 16006 S!
48. ***Calycogonium heterophyllum*** Naud. ssp. ***maculatum*** (Urb. et Ekm.) Borhidi **comb. et stat. nov.** — Basionymon: *Calycogonium maculatum* Urb. et Ekm. Ark. Bot. 21A 7: 44 (1927). The Hispaniolan taxon is obviously very closely related to the East Cuban *C. heterophyllum* Naud., therefore I suggest considering it as a Hispaniolan subspecies of the latter taxon.
49. ***Mouriri myrtilloides*** (Sw.) Poir. ssp. ***acuta*** (Griseb.) Morley = *Mouriri acuta* Griseb.

Ericaceae

W. S. JUDD published an excellent monograph on the genus *Lyonia* in the Journal of the Arnold Arboretum, vol. 62. He recognized and described two new species: *L. trinidadnesis* in Cuba and *L. alainii* in Hispaniola, and two new varieties in Cuba, reduced a number of species etc. I agree with most of his decisions, but in some cases I prefer to use a different interpretation of the taxa. These are the following:

50. ***Lyonia truncata*** Urb. ssp. ***montecristina*** (Urb. et Ekm.) Borhidi **stat. nov.** — Basionymon: *Lyonia montecristina* Urb. et Ekm. Ark. Bot. 24A; 4: 33 (1932). Syn.: *Lyonia truncata* var. *montecristina* (Urb. et Ekm.) Judd J. Arn. Arb. 62: 344 (1981). — The ssp. *montecristina* is obviously an allopatric taxon which has a completely separate distribution range, and an important argument for considering it as a subspecies.
51. ***Lyonia rubiginosa*** (Pers.) G. Don
 - ssp. ***rubiginosa***
 - ssp. ***costata*** (Urb.) Borhidi **stat. nov.** — Basionymon: *Lyonia costata* Urb. Symb. Ant. 7: 316 (1912). — Syn.: *L. rubiginosa* var. *costata* (Urb.) Judd J. Arn. Arb. 62: 354 (1981). — Hispaniola
 - ssp. ***stahlia*** (Urb.) Borhidi **stat. nov.** — Basionymon: *Lyonia stahlia* Urb. Symb. Ant. 5: 543 (1908). — Syn.: *L. rubiginosa* var. *stahlia* (Urb.) Judd J. Arn. Arb. 62: 355 (1981). — Porto Rico.

52. *Lyonia nipensis* Urb. ssp. *depressinerva* (Judd) Borhidi **stat. nov.** — Basionymon: *L. nipensis* var. *depressinerva* Judd J. Arn. Arb. 62: 378 (1981).
53. *Lyonia longipes* Urb. is a very distinct good species, I prefer to maintain it.
54. *Lyonia latifolia* (A. Rich.) Griseb. ssp. *calycosa* (Small) Borhidi **stat. nov.** — Basionymon: *Xolisma calycosa* Small N. Am. Fl. 29 (1): 67 (1914). — Syn.: *Lyonia calycosa* (Small) Urb. Feddes Repert. 22: 42 (1925). *L. latifolia* var. *calycosa* (Small) Judd J. Arn. Arb. 62: 396 (1981).
55. *Lyonia glandulosa* (A. Rich.) Urb. ssp. *revolutifolia* (Judd) Borhidi **stat. nov.** — Basionymon: *L. glandulosa* var. *revolutifolia* Judd J. Arn. Arb. 62: 402 (1981).
56. *Vaccinium leonis* Acuña et Roig = *Vaccinium giganteum* Bisse syn. nov.

Bignoniaceae

57. *Doxantha unguis-cati* (L.) Rehder = *Macfadyenia unguis-cati* (L.) A. H. Gentry Brittonia 25 (3): 236 (1973).

Gesneriaceae

58. *Dalbergaria cubensis* (Urb.) Borhidi **comb. nova** — Basionymon: *Columnea sanguinea* Hanst. var. *cubensis* Urb. Symb. Ant. 2: 359 (1901). — Syn.: *Columnea cubensis* (Urb.) Britt.

Acanthaceae

59. *Justicia calcicola* (Urb.) Alain var. *maestrensis* (Urb.) Borhidi **comb. et stat. nov.** — Basionymon: *Drejerella maestrensis* Urb. Symb. Ant. 9: 124 (1923). — *D. maestrensis* is apparently a little flowered variety of *J. calcicola*.
60. *Apassalus diffusus* Nees var. *glabratus* (Urb.) Borhidi **comb. nova** — Basionymon: *Dischoriste diffusa* Nees var. *glabrata* Urb. Ark. Bot. 22A 8: 90 (1929).

Rubiaceae

A comparative revision of the Greater Antillean taxa of some critical genera — as *Rondeletia*, *Antirhea*, *Machaonia*, *Scolosanthus* and *Phialanthus* is going on. As the first results of this work were published the separation of the genera: *Acunaeanthus*, *Roigella*, *Suberanthus* was carried out and the reconstitution made of the genera *Rogiera* and *Arach-*

nothryx for the Central American taxa of *Rondeletia* (see BORHIDI and FERNANDEZ 1981a and b, BORHIDI 1982, BORHIDI, JÁRAI-KOMLÓDI and MONCADA 1980). In the following some new taxa and critical remarks are published.

A) Some new *Rondeletia* from Hispaniola

61. *Rondeletia crassinervis* Borhid: spec. nova

Frutex cca. 1 m altus; rami hornotini compressi, pilis griseo-albidis adpressis dense retrorse sericei, internodiis 1–5 mm longis, veteriores lateraliter extensi, breves, virgati, rariter pungentes. Stipulae late triangulares 1–1,5 mm longae, in mucronem 0,5–1 mm longam terminatae. Folia opposita, subsessilia, 0,4–0,7 mm longe petiolata, late ovata vel cordiformia, basi cordata vel rotundata rariter truncata vel obtusa, apice abrupte acuminata et mucronato-acuta, 3–6 mm longa et 2–4 mm lata, nervis supra nullis, subtus utroque latere 2–3 sub angulo 60–80° abeuntibus, crasse prominentibus et dense prominenter reticulatis, lamina concave convoluta, supra dense sericea, subtus ad nervos albo-sericea inter nervos griseo-tomentosa, utrinque opaca, margine integra, crasse coriacea.

Flores solitarii axillares, 1–1,5 mm longe pedicellati, bractee binae inaequilongae, lineari-subulatae, brevior dimidio hypanthii, longior hypanthio aequilonga, usque ad 3–4 mm longa. Calycis tubus 4-angulatus, 1,5 mm longus et dense sericeus, lobi 4, triangular-subulati, basi 0,5 mm longe connati, pars libera 1,5 mm longa, tubo corollae aequilonga vel paullo superans. Corolla verisimiliter purpurea, tubus cca 2 mm longus superne non ampliatus, extus dense retrorse pubescens, lobi 4, orbiculari-ovata, extus pubescentes, intus glabri. Stamina 4, antherae oblongae sub fauce affixae. Stylus 2 mm longus, basi breviter pilosus, apice bilobatus, stigmata filiformia, 1 mm longa. Capsula globosa 2,5–3 mm longa lobis calycis 3–3,5 mm longis coronata loculicide dehiscens. Semina usque ad 0,5 mm longa, oblonga, angulata, punctulata exalata.

Holotypus: LEONARD 13864; Haiti; rocky slope West of bay Port à l'Écu (GH).

Species proxima, *R. Fuertesii* Urb. a specie nostra foliis majoribus, oblongo-ovatis, basi angustatis vel cuneatis, nervis lateralibus 2–5 paribus, sub angulo 25–30° abeuntibus, laminis planis, calycis lobis brevioribus, seminibus majoribus, reticulatis differt.

62. *Rondeletia filisepala* Borhidi spec. nova

Frutex valde ramificatus, virgatus, rami laterales tenues, flexuosi, longi, breviter ferrugineo-puberuli, internodii 0,7–1,5 mm longi. Stipulae late triangulares vel semi-orbiculares, 1–1,5 mm longae, rotundatae, brevissime mucronulatae. Folia opposita sessilia, oblongo-ovata, 0,8–2 cm longa et 4–12 mm lata, basi rotundata vel truncata, apice longe attenuata, apiculata et acuta, breviter mucronata, nervo medio utrinque prominulo, lateralibus 2–4 utrinque prominulis, supra anastomosantibus, subtus obsoletioribus, lamina supra nitida, minute papillosa, subtus concolora, minutissime punctulata et calloso-tuberculata, subtus ad nervum medium sparsissime adpresse pilosa, ceterum glabra, margine plana, chartacea. Inflorescentiae in ramis lateralibus terminales, trifurcatae, subumbellatae. Pedunculi 3–7 mm longi, ferrugineo-puberuli; bractee euphyl-

loideae, lanceolatae sessiles, acutae et longe apiculatae, 3–5 mm longae. Pedunculi 1–3-flori, puberuli, flores sessiles, bracteolae 2 lineari-subulatae, flexuosae, 3–4 mm longae. Calycis tubus globosus hirsutus, lobi 4–5, lineari-subulati, flexuosi, hirsutis, 3–4 mm longi. Corolla infundibuliformis, 7–8 mm longa, tubus tenuis, 0,5–1 mm crassus, extus retrorso hirsutus, intus glaber, lobi 4–6, orbiculares, 1–1,5 mm longi, anillum fauciale glaber, bene evolutum Stamina 4–5 sub fauce tubum affixa, antherae ellipticae cca 2 mm longae.

Holotypus: HOLDRIDGE 960. Haiti, Morne l'Hôpital, Port au Prince 40 m.s.m. (NY); **isotypi:** US, GH, BM, MICH.

Specimina examinata: LEONARD 10118, ibidem, NY, US, GH; — EKMAN H 5382 Massif de la Selle, Croix des Bouquets, gorge of Riv. Cul-de-Sac, GH, K, S, US; — BUCH 1165, Morne de l'Hôpital, GH, US; EKMAN H 2090, Port au Prince, Montfleury, S.

A specie proxima, *R. virgata* Sw. foliis apiculatis et acutis mucronatisque, bracteis lanceolatis, calycis lobis lineari-subulatis, flexuosis non reflexis, hypanthio corollaque hirsutis differt.

63. *Rondeletia feketiana* Borhidi spec. nova

Frutex usque ad 2 m altus, erectus vel scandens; rami hornotini teretes, striati, antrorse patenter hirsuti, fertiles internodiis densissime confertis, dense villosi, veteriores glabri et lenticellis rotundatis parvis, dense dispositis verrucosi. Stipulae triangulares, acutae, 4–5 mm longae, villosae. Folia ovata vel elliptica, 3–10 cm longe petiolata, ad apicem ramorum valde conferta, 1,5–5 cm longa et 1–2,5 cm lata, basi angustata et longe in petiolum protracta, antice rotundata et abrupte acuminata et apiculata, acuta; nervo medio supra impresso, subtus prominenti, lateralibus utroque latere 4–5 sub angulo 40–50° abeuntibus, arcuatis, ante marginem conjunctis, supra impressis et obsolete reticulatis, subtus prominentibus et densissime reticulatis, lamina supra opaca, viridis, pilis longis, basi incrassatis scabridulo-pilosa, subtus flavicanti-viridis, ad nervos longe villosula, inter nervos glabra, margine integra, leviter recurva, chartacea.

Flores in axillis densissime confertis, solitarii. Bractae lanceolatae, 3 mm longae, inter sese et stipulis basi connatae. Calycis tubus 3 mm longus, supra ovarium 1 mm longe prolongatus, extus villosus, intus adpresse sericeus, lobi 4, lanceolato-subulati, 3–4 mm longi, acuti, villosi. Corolla 12–14 mm longa, pallide orangeata, tubus 10–12 mm longus et 1 mm crassus, extus retrorse pilosus intus glaber; lobi 4 rotundati, 2,5–3 mm longi, utrinque glabri. Stamina 4, in fauce corollae insertae, antherae oblongae, 2 mm longae, subsessiles, subbasifixae, filamente 0,5 mm longa, filiformia, glabra. Stylus 6–7 mm longus, glaber, apice 2 mm longe bilobatus lobi filiformes. Capsula depresso globosa, 3,5 mm longa et 4 mm lata, superne villosa, extus pilis e tuberculis suberosis in fasciculis abeuntibus dense pubescens. Semina ovalia, 2 mm longa, 1 mm lata, obscure brunnea, lateraliter compressa, exalata.

Holotypus: ALAIN H. LIOGIER 18469; Dominican Republic; on limestone rocks, near Abreu, about sea level (NY).

Specimina examinata: ALAIN H. LIOGIER 16149. Dominican Republic; On rocks near the base of the cliffs, near Abreu, 20–30 m.s.m. (NY).

Hanc speciem in honorem Prof.-ris G. FEKETE Hungariae in oecologia atque in sociologia plantarum excellentissimi dedicavi

64. *Rondeletia liogieri* Borhidi spec. nova

Frutex usque ad 20 cm altus, erectus; rami hornotini 4-anguli, striati et antrorse dense albo-pubescentes et tomentosi, veteriores teretes, glabrescentes. Folia ovata vel elliptica, 2–5 mm longe petiolata, basi rotundata vel obtusa et abrupte in petiolum protracta, apice rotundata, breviter apiculata et mucronulato-acuta, 1,5–2,5 cm longa et 8–17 mm lata, nervo medio supra impresso, subtus prominente, lateralibus utroque latere 3–5, sub angulo 60–80° abeuntibus, arcuatis supra ante marginem conjunctis et obsolete reticulatis, subtus crasse prominentibus et densissime reticulatis, lamina supra opaca et strigilloso-puberula, subtus ad nervos pilis mollibus pubescens, inter nervos luteo- vel brunnescenti-luteo tomentosa, margine integra, leviter recurva, chartacea.

Flores in axillis solitarii, sessiles. Bracteae lineares, 3–4 mm longi, pubescentes, saepe stipulis triangularibus tomentosis connatae. Calycis tubus 3 mm longus, pubescens, supra ovarium 1–1,3 mm longe prolongatus, intus adpresse sericeus; lobi 4, lineares vel subspathulato-lineares, supra medium leviter dilatati, apice obtusi, per pares inaequilong, 3,5–4,5 mm longi, pubescentes. Corolla 10–12 mm longa colore orangeato, tubus 8–10 mm longus et 0,8 mm crassus, superne paullo ampliatus, extus retrorse puberulus, intus glaber; lobi 4, oblongo-ovati, 2,5–3 mm longi, extus strigilloso, intus papilloso-puberuli. Stamina 4, sub fauce inserta, subsessilia, antherae lineares, 2 mm longae, filamenta 0,5 mm longa. Stylus 7 mm longus, apice 1 mm longe bilobatus.

Holotypus: ALAIN H. LIOGIER 10986a; Dominican Republic; Sosua, on rocks facing the beach (NY).

A specie proxima *R. feketiana* Borhidi, ramis albo pubescentes et tomentosuli, foliis basi rotundatis, subtus inter nervos dense tomentosis, calycis lobis lineri-oblongis vel oblongo-spathulatis inaequilongis, apice obtusis, lobis corollinis utrinque pubescentibus differt.

65. *Rondeletia exasperata* Borhidi spec. nova

Habitu *Rondeletiae heterochroae* Urb. similis sed ab eo foliis nervis lateralibus supra impressis, subtus reticulatis atque floribus axillaribus solitariis certe distat. A specie proxima, *Rondeletia feketiana* Borhidi stipulis longe aristatis, foliis lanceolatis, utrinque attenuatis et acutis, 1–2,5 cm longis et 5–15 mm latis, nervis lateralibus 2–3 sub angulo 20–30° abeuntibus, supra inconspicue, subtus obsolete reticulatis, lamina supra glabra, subtus ad nervos puberula inter nervos valde adpresse tomentosa, bicolora, seminis 1 mm longis, ellipticis, circumcirca fimbriato-alatis certe specificè differt.

Holotypus: ALAIN H. LIOGIER 18960; Dominican Republic; Los Haitises, Pinacón, Bayaguana, alt. 150 m (NY).

B) Some notes on Hispaniolan *Antirhea* species

66. *Antirhea acutata* (DC.) Urb.

— ssp. **acutata**: stipulis mucronato-apiculatis, saepe recurvatis, foliis plerumque majoribus, utrinque manifeste reticulatis, inflorescentiis 4–8-floris, corolla 10–14 mm longa.

— ssp. **elliptica** (Urb. et Ekm.) Borhidi **comb. et stat. nov.**: stipulis triangulari-acutis, non mucronatis, foliis minoribus, nervis utrinque obsole-

tis, inflorescentiis 2–4-floris, corolla 7–9 mm longa. — **Basionymon:** *Antirhea elliptica* Urb. et Ekm. Ark. Bot. 24A 4: 52 (1932).

67. *Antirhea myrtifolium* (Griseb.) Urb. = *Antirhea montecristina* Urb. syn. nov.
68. *Antirhea sintenisii* Urb. is probably an endemic species to Porto Rico. All the revised Hispaniolan specimens determined as *A. sintenisii* proved to be *Antirhea granulata* (Griseb.) Urb. (see EKMAN H 14900, H 19962, H 15509).
69. *Antirhea pitoniana* Urb. is a good endemic species of Hispaniola. It is also closer related to *A. granulata* (Griseb.) Urb. than to *A. sintenisii*.
70. *Antirhea radiata* (Griseb.) Urb. was described from Cuba and later reported also from Hispaniola. The only specimen seen from Hispaniola is the H 10149 of EKMAN, which differs notably from the Cuban population and which ought to be distinguished at least at subspecific level.
- ssp. **radiata**: arbor grandis vel mediocris foliis ovatis vel ellipticis subtus domatiatis vel scrobiculatis, nervo medio barbato.
- ssp. **haitiensis** Borhidi ssp. **nova**:
- Arbor parva foliis obovatis, non domatiatis vel scrobiculatis, nervo medio glabrescente.
- Holotypus: EKMAN H 10149; Haiti; Morne de la Hotte, Western group, Jérémie, Morne Martin steep hillside, cca 700 m.s.m. 23. 7. 1928 (S).

71. *Antirhea ekmanii* Borhidi spec. **nova**

Arbor parva. Rami teretes, minute adpresse sericei, longitrorse sulcati, ad apicem foliigeri. Stipulae interpetiolares late triangulatae, dorso leviter carinatae, 2 mm longae, apice acutae vel minutissime mucronulatae vel denticulatae, patentes, glabrae. Folia 1–3 mm longe petiolata, petiolo crasso et glabro suffulta, lanceolata vel elliptica, utrinque subaequaliter angustata, basi attenuata et in petiolum protracta, apice acuminata et 1 mm longe spinoso-mucronata, 2–4 cm longa et 0,6–1,5 cm lata, nervo medio supra prominulo, subtus carinato-prominenti, lateralibus utrinque dense et tenuiter reticulatis, reticulo utrinque prominulo, lamina supra nitida, subtus pallidiora, saepe ad nervum medium medio 2-scrbiculata, utrinque glabra, coriacea. Inflorescentia axillaris vel subterminalis 2-flora. Flores sessiles, pedunculi, pedicellique nulli. Tubus calycis obovatus, 1 mm longus et latus, glaber, lobi valde inaequales, 1–3 mm longi glabri. Corolla glabra, solummodo valde destructa visa. Fructus viridis oblongo ellipticus, 8–9 mm longus et 3–4,5 mm crassus, glaber, apice, lobis calycinis 4 inaequalibus, oblongo-ovatis vel lanceo-linearibus, 1 valde minori coronatus.

Holotypus: EKMAN H 15429. Santo Domingo, Cordillera Central Prov. de Samaná, Los Haitises, Boca del Infierno. Limestone crags. 25. 6. 1930.

Obs.: Verisimiliter *A. albobrunae* Urb. et Ekm. affinis inflorescentiis sessilibus et foliis pungentibus, sed ab ea foliis lanceolatis, utrinque multinerviis, subtus medio scrobiculatis, forma sepalorum et fructibus grandis optime differt.

C) A new *Machaonia* from Hispaniola72. *Machaonia leonardorum* Borhidi spec. nova (Fig. 1.)

Frutex 2–3 m altus, valde spinosus. Rami hornotini 4-anguli, pilis rigidis albis dense breviterque villosi, veteriores teretes, brunnei reticulariter striati et lenticellis orbicularibus sparse dispositis suffulti, laterales breves, in spinas plerumque trifurcatas 5–15 mm, longas excurrentes. Stipulae semiorbiculares 0,2–0,4 mm longae, apice mucronatae, dense hirsutae. Folia opposita vel in nodis ramorum veteriorum fasciculata, ± 1 mm longe petiolata ovata vel elliptica, antice angustata, apice ipso acuta vel obtusa, basi rotundata, obtusa vel breviter in petiolo angustata, 4–15 mm longa et 2–7 mm lata, sub medio latissima, nervo medio supra usque ad medium breviter impresso, apicem versus evanescente, subtus prominulo, lateralibus utroque latere 1–2 supra obsoletis, subtus tenuiter prominulis, plerumque utrinque nullis; lamina utrinque pilis brevibusque mollibus dense lanuginosa et subtus in nervis strigilloso-hirsuta, membranacea.

Inflorescentiae terminales vel laterales, cymoso-umbellatae, multiflorae. Flores subsessiles. Calyx obpyramidatus, 1,3–1,5 mm longus, basi cuneatus, acutus, lobi tubo plerumque aequilongi triangulares, apice acuti cum tubo densissime hirsuti. Corolla flavo-virescens (LEONARD in schaed.) non visa. Fructus obpyramidalis, 2,5–3,5 mm longus, superne 2 mm latus, basi acutus, apice lobis calycinis lanceolato-triangularibus, 1–1,5 mm longis, apice acutis, coronatus, cum lobis hirsutus.

Holotypus: E. C. and G. M. LEONARD 12755. Haiti; Vicinity of Jean Rabel, plateau above Bord de Mar, 27. Jan.–9. Febr 1929 (A); isotypes: F, US.

Obs.: Forma, textura et indumento foliorum *Machaoniae pubescentis* Borhidi et Fernandez (e Cuba Meridionali) affinis, sed ab ea forma calycis fructusque clare differt. Ab altera specie sympatrica huius generis *M. haitiensis* Urb. et Ekm. foliis utrinque lanuginosis, lobis calycinis acutis statim distinguitur.

D) Some new *Phialanthus* from Cuba73. *Phialanthus glaberrimus* Borhidi spec. nov.

Frutex vel arbor parva. Rami leviter 4-anguli, brunnei, resinoso-tuberculati, plerumque glabri, veteriores teretes cinerei internodiis 2–6 mm longis foliis dense conferti. Stipularum vagina truncata 3 mm longa, granulata, glabra. Folia 2–3 mm longe petiolata, obovata vel late oblanceolata, basi angustata, antice rotundata vel brevissime apiculata, apice ipso obtuso, 2,5–4,5 cm longa et 1–2 cm lata, nervo medio supra impresso, subtus prominente, lateralibus utrinque nullis. Lamina in sicco utrinque cinerea, opaca, glabra, margine tenuiter recurva, subcoriacea.

Inflorescentiae axillares, sessiles triflorae essentialiter glabrae. Involucrum sessile, late cupuliforme, 2,5 mm altum, 4 mm in diam., truncatum sine denticulis minute crenulatum, glabrum. Flores sessiles glabrae. Calycis tubus 4-angulus obpyramidalis 2,2 mm longus, lobi 4, ovati, tubo aequilongi, nitidi, rubri, carnosii, reticulo nervorum prominulo. Cetera non visa.

Holotypus: HAJB 27393. Baracoa; Loma de Buena Vista 500–600 m.s.m. Leg.: ALVAREZ, BISSE, MEYER 12. 8. 1975.

74. *Phialanthus guantanamensis* Borhidi spec. nova.

Frutex vel arbor parva. Rami hornotini 4-anguli densissime hirsuti, abunde resinosi, internodiis 2–8 mm longis, dense foliosi. Stipularum vagina leviter 4-lobata vel truncata, 1 mm longa, resinosa et hirsuta.

Folia 1–1,5 mm longe petiolata, oblongo-elliptica, 6–14 mm longa et 2,5–5 mm lata, utrinque attenuata, apice obtusa, nervo medio supra impresso, subtus prominenti, lateralibus utrinque nullis, lamina supra nigrescens, nitidula, subtus in sicco ferruginea et opaca, utrinque glabra, margine revoluta, subcoriacea.

Inflorescentiae axillares, sessiles, 3-florae. Involucrum infundibuliforme, 1 mm longum, antice 1 mm latum, superne lobum 1 late triangularem et 3 dentes breves et denticulos interjectos gerens, extus breviter hirsutum. Flores sessiles. Calycis tubus cylindraceus 1,2 mm longus, dense puberulus, lobi 4, lineari-oblongeolati, apice obtusi, extus pilosi, 1,2 mm longi. Corolla 3 mm longa, tubus 2 mm longus e basi anguste cylindraceo 0,5 mm longo abrupte dilatatus 2 mm longus, lobi 4, ovati, apice rotundati, 1 mm longi. Stamina 4 mm longa e corolla longe exserta, filamenta supra basim tubi corollini in alt. 0,5 cm inter sese connata et ad tubum adnata. Cetera non visa.

Holotypus: HAJB 3517. Guantánamo, monte seco sobre diente de perro en la subida a Monte Cristi, 300 m.s.m. Leg.: BISSE et ROJAS. Jun. de 1967.

75. *Phialanthus inflatus* Borhidi spec. nova

Frutex vel arbor parva. Rami juniores teretes, dense retrorse hirsuti, internodiis 3–8 mm longis suffulta, veteriores cinerei glabri. Stipularum vagina 1–1,5 mm longa, irregulariter lobulata vel truncata, margine fimbriata, hirsuta. Folia 0,5–3 mm longe petiolata, elliptico-oblonga, plerumque supra medium latissima, 1–3 cm longa et 3–8 mm lata, basi longe attenuata et cuneata, apicem versus leviter apiculata apice ipso rotundato vel truncato, rariter brevissime emarginato, nervo medio supra impresso, subtus prominenti, lateralibus utrinque nullis; lamina supra opaca, brunneo-marmorata, subtus opaca, flavicans, valde discolor, dense papillosa et sparse minuteque glanduloso-punctulata, utrinque glabra, margine valde revoluta, coriacea. Inflorescentiae axillares, 1–1,5 mm longe pedunculatae, 5–7-florae; involucrum cylindraceum, 0,7–1 mm longum, sicut pedunculus glabrum, margine fimbriatum, superne breviter 2-dentatum vel truncatum. Flores 2–3 mm longe pedicellati, pedicelli medio articulati, inferne pilosi vel glabri. Tubus calycis 2 mm longus, ovatus, basim versus ampliatus, 8-costulatus, basi truncatus, lobi 3–3,5 mm longi, oblongo-obovati vel spathulati, glabri. Corolla non visa. Calyx fructiferus manifeste 8-costatus, inflatus, basi 2 mm latus, glaber.

Holotypus: HAJB 5756. Cuba, Prov. Guantánamo (Oriente); Baracoa, charrascales cerca de la desembocadura del arroyo Maguana. — Leg.: J. BISSE et E. KÖHLER, febr. 1968. Isotypus: JE.

76. *Phialanthus macrocalyx* Borhidi spec. nova

Frutex vel arbor parva. Rami hornotini teretes striati, nigro-brunnei, sparse brevissimeque pilosi, demum glabri, internodiis ad ramos 6–12 cm, ad ramulos 1,5–6 cm longis. Stipularum vagina 2–2,5 mm longa, antice truncata. Folia 2–4 mm longe petiolata, elliptica, medio vel sub medio latissima, basim versus in petiolum angustata vel obtusiuscula, antice obtusa et brevissime truncata 2,5–5 cm longa et 1,2–2,5 cm lata,

nervo medio supra impresso, subtus prominenti, lateralibus utroque latere 6–10 supra obsoletis vel inconspicuis, subtus nullis, lamina glabra supra nigricans subtus flavescens, utrinque opaca, margine tenuiter-recurva, subcoriacea. Inflorescentiae axillares, 0–1,5 mm longe pedunculatae, 7-florae. Involucrum 3–3,5 mm longum inferne attenuatum, superne 3 mm latum, truncatum, irregulariter crenulato denticulatum hirsutum. Flores 4-meri breviter (0,5–1 mm longe) pedicellati, tubus calycis cylindraceus, basi leviter obliquus, 4 mm longus, breviter pilosus, lobi oblongo-ovati vel oblongo-obovati, apice obtusi vel rotundati, 5–6 mm longi et 2 mm lati, glabri. Cetera non visa.

Holotypus: HAJB 17596. Prov. Oriente, Sierra de Moa, Charrascal del Cayo Coco, 200–300 m alto. 13. 8. 1970. Leg.: BISSE et LIPPOLD.

77. *Phialanthus macrostemon* STANDLEY

Contr. U. S. Nat. Herb. 20: 209 (1919) Typus: Roig 143. Baracoa, Pinar de Cabonico

Adde ad descriptionem: Involucrum late infundibuliforme 3 mm profundum basi 3 mm, superne 5 mm latum, manifeste 4-lobatum, lobi laterales 2, ovati vel obovati \pm integri 1,5–2 mm longi, intermedii 2 late triangularii irregulariter dentati vel fimbriati, 1–1,5 mm longi, flores 5–8 sessiles, calyx et hypanthium glabrum, 1–1,2 mm longum, lobi 4, lineari-oblongi, apice rotundati, tubo \pm 2-plo longiores, 2 mm longi, glabri, ex involuero vix exserti. Corolla 4–4,5 mm longa, tubus superne anguste dilatatus, 3 mm longus, basi 0,3 mm latus cylindricus, superne 4-angulatus, 1–1,8 mm latus, lobi ovati, apice obtusi 1–1,5 mm longi. Stamina 4 e lobis corollinis non vel vix exsertae, filamenta basi in tubo 1 mm longe connata et basi ad tubum adnata, 3–3,5 mm longa, glabra, antherae ovatae 0,7–1 mm longae. Stylus insertus 3,5 mm longus.

78. *Phialanthus marianus* Borhidi spec. nova

Frutex vel arbor parva. Rami hornotini leviter 4-anguli, brevissime patentipilosi, internodiis ad ramos 1,5–3,5 cm, ad ramulos 0,4–1,5 cm longis. Stipularum vagina 1–1,5 mm longa, breviter 4-lobulata, lobuli majores subulati, 0,3–0,5 mm longi, minores acuti 0,1–0,2 mm longi.

Folia 1–2 mm longe petiolata, petiolis breviter hirsutis suffulta, oblongo-lanceolata, vel elliptico-oblonga, plerumque medio vel submedio latissima antice leviter apiculata et obtusa, basi longe attenuata, 1,5–2,5 cm longa et 0,3–0,7 cm lata, nervo medio supra per totam longitudinem impresso, subtus prominenti, lateralibus utrinque nullis, margine anguste recurva et strigilloso-pilosa, supra nitentia subtus valde discolora, opaca, subcoriacea. Inflorescentiae axillares 1–2 mm longe pedunculatae, 3-florae. Involucrum breviter campanulatum hirsutum, bidentatum dentibus, minutis interjectis, vel truncatum et irregulariter denticulatum 1–1,5 mm longum. Flores subsessiles 4-meri. Calycis tubus obconicus, 1,5 mm longus, glaber, lobuli elliptici vel spatulati tubum duplo superantes 3 mm longi, 1,6–2 mm lati. Cetera non visa.

Holotypus: HAJB 36587. San Antonio del Sur, Abra Mariana, loma al oeste del barranco. Leg.: BISSE, DIAZ, GONZALEZ, STOHR, 6. 2. 1978.

79. *Phialanthus acunae* Borhidi spec. nova

Frutex vel arbor parva. Rami juniores teretes, dense breviterque hirtuli, internodiis 2–5 mm longis, dense foliosa. Stipularum vagina 1–1,2 mm longa, leviter bilobata, puberula. Folia 0,5–2 mm longe petiolata, elliptico-oblonga, 5–12 mm longa, 2–5 mm lata, basi angustata antice rotundata, nervo medio supra impresso, subtus prominenti, lateralibus utrinque nullis, lamina supra puberula, postremo glabra, nitida, subtus dense



Fig. 4. *Scolosanthus howardii* Borhidi sp. n. (delined by Mrs. Gizella GYURKÓ, based on the type specimen). A: habit; B: fruit; C: flower; D: longitudinal section of the corolla; E: ramification; F: leaf



Fig. 3. *Scolosanthus hispidus* Borhidi sp. n. (delined by Mrs. Gizella GYURKÓ, based on the type specimen). A: habit; B: flower; C: leaf; D: transversal section of a leaf



Fig. 2. *Scolosanthus acunae* Borhidi et Muñiz sp. n. (delined by Mrs. Gizella GYURKÓ, based on the type specimen). A: habit; B: flower

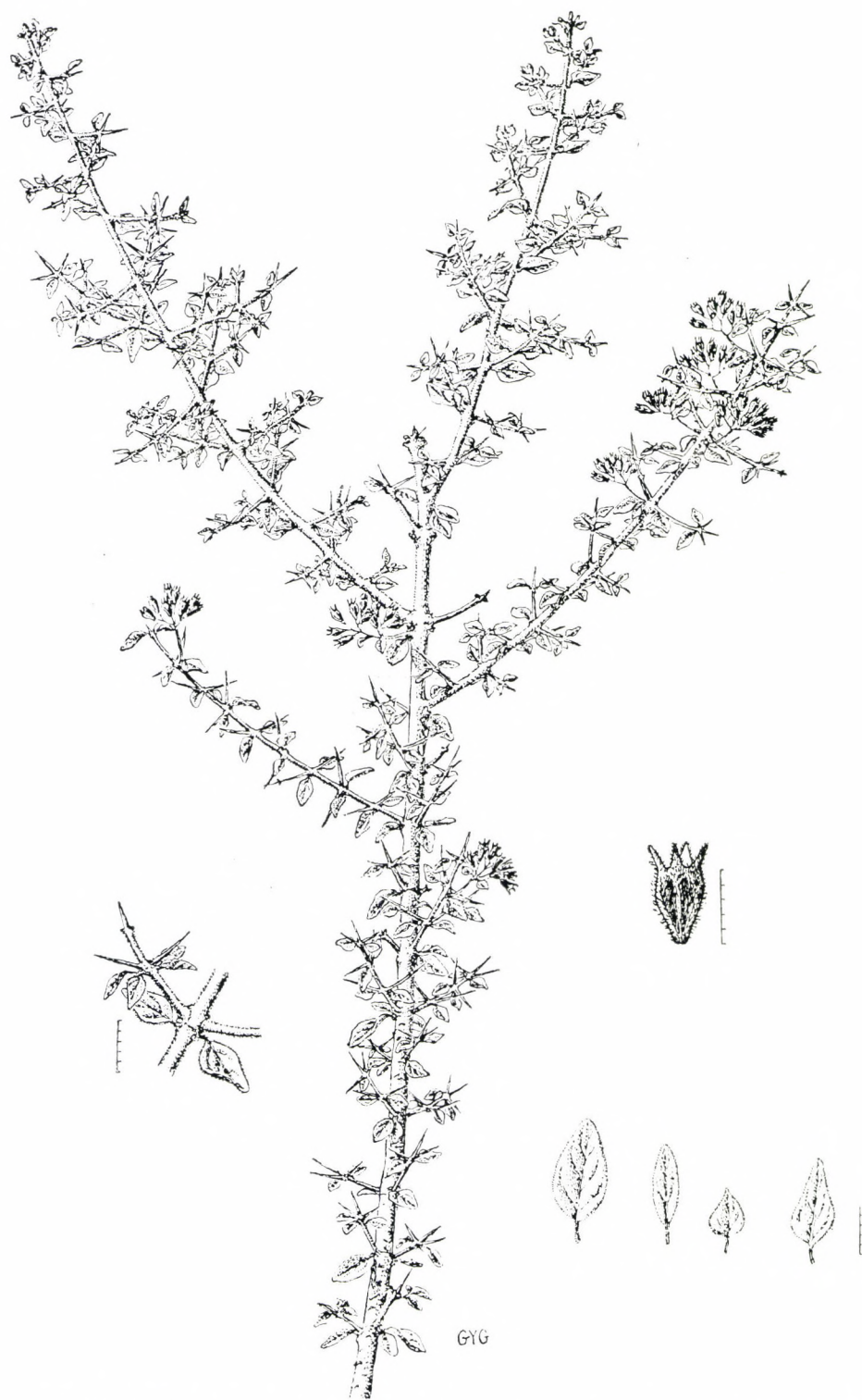


Fig. 1. *Machaonia leonardorum* Borhidi sp. n. (delined by Mrs. Gizella GYURKÓ, based on the type specimen)

papilloso-punctata, flavicans et opaca, margine revoluta, coriacea. Inflorescentiae axillares sessiles vel 0,5 mm longe pedunculatae, 3–5-florae. Involucrum 0,7–1 mm longum cylindraceum, antice truncatum, pilosum. Flores 1–2 mm longe pedicellati, tubus calycis cylindraceus, 1–1,2 mm longus, pilosus, lobi 4, lineari-oblongi vel lineari-spathulati, 1,5 mm longi, extus sparse pilosi. Corollae tubus 4-angulatus, 1 mm longus, lobi 4, ovati apice rotundati, 2 mm longi. Stamina 4, corolla breviora, filamenta supra basim tubi corollini per pares connata et ad tubum adnata, 2 mm longa, antherae 0,8 mm longae, ovatae, basifixae. e tubo vix exsertae Stylus 3 mm longus, superne paullo dilatatus, brevissime bilobato-capitatus. Calyx fructiferus oblongo-ellipticus, 2,5–3 mm longus, leviter bilobatus, satis dense pilosus; lobi calycini oblongo-elliptici vel oblongo-spathulati, fructu aequilongi, sparse pilosi.

Holotypus: ALAIN 975, (CLEMENTE 6879) HAC. Cuba; Oriente; Camino de Centeno, Cananova. Jul. 1949 CLEMENTE, ALAIN et CRISÓ-GONE. Isotypi: BP, GH, US.

Specimina examinata: Región de Moa, Mina Delta, M. VICTORIN, CLEMENTE et ALAIN. LEÓN 21830, HAC. — HAJB. 17863; Moa; Charrascal al este de Yamanigüey. BISSE et LIPPOLD, 15.8.1970.

E) New taxa of *Scolosanthus* from the Greater Antilles

80. *Scolosanthus acunae* Borhidi et Muñiz spec. nova (Fig. 2.)

Frutex ramosus spinosusque, usque ad 2–3 m altus. Rami hornotini veterioresque teretes, pilis basi dilatatis et patentibus granulato-scabrosi, resinosi, apice in spinam trifurcatam, cruciformem, usque ad 1–1,5 cm longam excurrentes; rami laterales spinae leviter recurvati. Stipulae interpetiolares semiorbiculares vel rhombeae, apice rotundatae, in annulum connatae, demum dehiscenti-bilobatae, postremo fissurato-dissectae, 1–2 mm longae. Folia opposita vel 4–8 in fasciculis axillaribus 1–2 mm longe petiolata, ovata et mucronato-apiculata, acuta, rariter mucronulato-spinulosa, plerumque recurva, basi obtusa, rotundata vel subcordata; nervo medio utrinque prominulo, subtus plerumque supra dimidium evanescente, lateralibus supra utroque latere 3–4, prominulis et obsolete anastomosantibus, subtus non vel tenuiter conspicuis; supra nitida, obscure viridia, papillosa vel papilloso-granulosa, subtus pallidiora, resinoso-papillosa, coriacea, margine revoluta. Flores 1–4, fasciculati in axillis foliorum; 5–6 mm longi, 3-meri, rarissime 4-meri, subsessiles. Calyx 2 mm longus; tubus calycis 1,5 mm longus, leviter compressus, 6–(8)-nervosus; lobi calycis 0,5 mm longi, plerumque 3, rariter 4, triangulares, acuti, dorso carinati, margine et dorso sparse ciliati. Corolla 3,5–4 mm longa, pallide flava, in alabastro 3–(4)-angula, tubus 2,5–3 mm longus, sub anthesi tubuloso-campanulata, lobi plerumque 3, rarissime 4, 0,6–1 mm longi, late triangulares, in anthesi valde recurvati. Stamina 3, rarissime 4, filamenta corollae basi adnata, in tertio inferiori inter sese coalita, supra dimidium pubescentia. Antherae lineares, apice rotundatae, basi affixae, in tubo corollae insertae. Stylus cylindricus, glaber, 4,5–5 mm longus e tubo corollae leviter exsertus, apice globosus, obsolete et minutissime bilobus. Ovarium inferum, 2-loculare; ovula in loculis solitaria, ad apicem loculi affixa, pendula, elliptica, lateraliter compressa. Fructus inferus, drupaceus, lobis calycis coronatus; exocarpium carnosum, album, endocarpium leviter lignosum, unilocularis, 1-spermus. Semen discoideum vel compresso-ellipticum, foveolatum.

Holotypus: Cuba, Prov. Pinar del Rio; Loma Cajálbana; in declivibus abruptis orienti-septentrionalibus, fruticetis sempervirentibus, solo

latosol serpentínico, in alt. 400 m.s.m. Leg.: A. BORHIDI, E. DEL-RISCO et R. CAPOTE, 21. Nov. 1974. flor. et fruct. No. 27694 SV! Isotypi: SV! et Bp!

Specimina examinata: Cajalbana, leg.: ACUÑA et CORREL 21627 SV! (ster.); — Este de Cajalbana, leg.: ALAIN et ACUÑA 1379 (ster.) SV! — Loma Preluda de Cajalbana, leg.: A. BORHIDI, E. DEL-RISCO et R. CAPOTE (ster.) 26. Nov. 1974. SV! — Ibidem, leg.: A. BORHIDI et R. CAPOTE 29. Jan. 1976. SV, Bp!

Obs.: Spinis trifurcatis, lateralibus recurvatis, floribus 3-meris ab omnibus aliis speciebus huius generis differt.

81. *Scolosanthus crucifer* Wr. in Sauv.

var. crucifer: foliis oblongo ellipticis, apice obtusis vel rotundatis, 7–15 mm longis, utrinque glabris.

Holotypus: Cuba; Ch. WRIGHT 377; Lagunas of Guama...chio (?) 3. aug. 1865 GOET! — isotypi: S! NY! HAC! US!

var. acutus Borhidi **var. n.:** foliis lanceolatis, apice breviter acuminatis et mucronato-acutis, 7–15 mm longis et 5–8 mm latis, utrinque glabris.

Holotypus: Cuba; Prov. Villa Clara (Las Villas, Sabanas de Motembo. Leg.: LEÓN et LOUSTALOT 9340; 9–10. Aug. 1930. HAC! — isotypi: GH! NY!

var. microphyllus Borhidi **var. n.:** foliis ellipticis vel suborbicularibus minutis, 2–6 mm longis et 1,5–4 mm latis, utrinque glabris, margine valde revolutis.

Holotypus: LEÓN 13066 HAC; Prov. Matanzas. Cuabal de Espinal, Canasi; Leg.: LEÓN et ACUÑA 16–18. aug. 1927. — Isotypus: ACUÑA 24693, HAC!

var. subtomentosus Borhidi **var. n.:** foliis ellipticis, subtus dense brevissimeque tomentulosis, 7–12 mm longis.

Holotypus: ROIG 4245 HAC; Prov. Matanzas, San Adrián, Cuabal de Espinal. — Leg.: ROIG et LEÓN 11. 4. 1927.

Specimina examinata: Prov. Matanzas: Serpentine barrens El Hatillo, Canasi, LEÓN 12971, GH, HAC, NY; — Matanzas: in fruticetis serpentinosi Loma Galindo, Corral Nuevo, A. BORHIDI et E. DEL-RISCO 30. 5. 1970. Bp 573612.

82. *Scolosanthus hirsutus* Borhidi spec. nova

Frutex ramosus et spinosus, usque ad 2 m altus. Rami hornotini veterioresque pilis patentibus breviter hirsuti vel demum granuloso-scabrosi, resinosi, apice in spinas simplices vel plerumque trifurcatas excurrentes. Rami centrales spinarum 5–10 mm longi, laterales sub angulo acuto (70–80°) abeuntes, 4–8 mm longi, pubescentes. Stipulae late triangulares, acutae, 1–1,5 mm longae, resinosa, solummodo basi connatae, demum deciduae. Folia opposita vel 4–8 in fasciculis axillaribus conferta, 1–2 mm longe petiolata, late vel orbiculari-ovata vel rhombo-orbicularia, 3–5 mm longa et 2–5 mm lata, apice breviter acuminata et mucronato-apiculata, plerumque reflexa, basi leviter cuneata vel obtusa vel truncata, nervo medio subtus inferne obsolete prominulo vel inconspicuo,

supra nullo, lateralibus utrinque nullis, lamina supra convexa, nitidula, densissime breviter hirsuto-hispidula, subtus opaca, pallida et dense hirsuta, margine valde revoluta, rigide coriacea.

Flores 1–4 fasciculati in axillis foliorum, sessiles. Calyx cum hypanthio oblongo-obovatus, 1–1,3 mm longus, lobi 4, brevissimi, 0,2–0,3 mm longi, triangulares, acuti, omnes breviter hirsuti. Corolla non visa. Fructus inferus, drupaceus, lobis calycinis coronatus, exocarpium album, carnosum, breviter adpresse ferrugineo-puberulum. Endocarpium leviter lignosum, unilocularis, unispermus.

Holotypus: 29922 HAJB; Cuba; Costa Sur de Baracoa (prov. Guantánamo), San Antonio del Sur, 4 km al Oeste del pueblo, 200–400 m sobre el nivel del mar. Leg.: A. ARECES, J. BISSE, J. GUTIERREZ et H. MANITZ, 10. Febr. 1976. — Isotypi: HAC, JE, BP.

Specimina examinata: LEÓN 17557 HAC; Cuba: Prov. Guantánamo (Oriente); Mesa de Chivo, Maisi. Leg.: P. MATOS, Jan. 1940.

Obs.: Forma foliorum species proximae *S. bahamensis* Britt. et *S. nannophyllus* Borhidi sunt. Ab eis *S. hirsutus* Borhidi calyce hypanthioque dense breviterque hirsutis statim discernendus est. Forma calycis et indumento species magis affinis *S. hispidus* Borhidi est, sed ab ea *S. hirsutus* foliis orbiculari-ovatis, enervibus, rigide coriaceis omnino differt.

83. *Scolosanthus hispidus* Borhidi spec. nova (Fig. 3.)

Frutex ramosus, spinosus. Rami hornotini levissime angulati, pilis basi tuberculatis hirsuti in spinam simplicem, rariter trifurcatam, 1–1,5 cm longam excurrentes, veteriores brevissime scabroso-pubescentes vel glabrescentes. Stipulae ad apicem ramorum tantum manifestae, late triangulatae cca 1–1,5 mm longae. Folia dense conferta, 1–2 mm longe petiolata, petiolis hirsutis suffulta, elliptica vel lanceolata, apice acuta vel obtusiuscula, brevissime vel non acuminata, basi breviter attenuata et in petiolum protracta, 8–15 mm longa et 4–8 mm lata, nervo medio utrinque prominenti, lateralibus utrinque nullis vel obsoletis, utrinque pilis basi tuberculatis dense pubescentia, postremo supra glabrescentia et muricato-scabra subtus dense granulato-punctata, supra nitida, subtus flavescentia et pallida manifeste discolor, margine integra, valde revoluta, chartacea. Flores in fasciculis axillaribus 2–5, subsessilia vel brevissime pedicellata. Hypanthium oblongo-obovatum, 1–1,5 mm longum, lateraliter compressum, dense hirsutum, calycis lobi 4, late ovati vel semiorbiculares, apice rotundati, dorso sparse hirsuti 0,5–1 mm longi. Corolla 2 mm longa, purpurea, infundibuliformis, tubus brevis, angustatus, lobi 4, late ovati, apice rotundati, extus hirsuti. Cetera non visa.

Holotypus: LEÓN 18110 SV. Cuba; Prov. Oriente (Guantánamo), Primera mesa de Maisi. Leg.: H. LEÓN et W. SEIFRIZ. Julio 1938.

Obs.: *S. leonardi* Alain (e Santo Domingo, Hispaniola) affinis, qui a specie nostra foliis nervo medio supra applanato nervis lateralibus supra prominulis, subtus molle pilosulis margine planis floribus ad spinas glomeratis, calycis lobis acutis differt.

84. *Scolosanthus howardi* Borhidi spec. nova (Fig. 4.)

Frutex ramosus, inermis usque ad 1,5 m altus. Rami hornotini 4-angulosi, longitudinaliter canaliculati vel striati, bifariam sparse minutissime scabriusculi ceterum glabri. Stipulae breviter connatae, annuliformes, glabrae margine brevissime et remote

denticulatae. Folia apice ramulorum conferta 1–3 mm longe petiolata, lanceolata vel oblanceolata, apice angustata et mucronato-acuminata, basi longe cuneata et in petiolum protracta 1–3 cm longa et 0,5–1,0 cm lata, nervo medio supra impresso, subtus prominente, lateralibus supra tenuiter prominulis, et dense reticulatis, subtus obsoletis vel nullis, lamina supra lucida, viridis, subtus opacior et pallida, margine revoluta, coriacea. Flores pauci 1–3 in axillis, 1–2 mm longe pedicellati, essentialiter glabri. Calycis tubus 1,5–2 mm longus, obovatus, lateraliter compressus, purpureo indutus, lobi 4, oblongo triangulares vel lanceolati, dorso punctulati glabri. Corolla purpurea, 3,0–4,0 mm longa, tubus angulatus superne parum ampliatus, 1–1,5 mm latus, lobi 4, ovati 0,7–1 mm longi. Stamina 4, filamenta 3 mm longa, tertio inferiori coalita superne 2 mm longe libera, per totam longitudinem pilosa, antherae oblongo-ellipticae 1,5–2 mm longae in tubo insertae. Cetera non visa.

Holotypus: Jamaica, Prov. Trelawny Ramgoat Cave district, Cockpit Country dry rocky hillsides about 500 m. Leg.: R. A. HOWARD and G. R. PROCTOR 14386. 4. Jul. 1956.

Specimina examinata: Jam. Prov. Trelawny "Mango Tree Hill" along road between Burnt Hill and Spring Garden, wooded limestone hilltop about 600 m. Leg.: G. R. PROCTOR and Bro. ALAIN 24899, 6. June 1964.

Obs.: *Scolosantho multiflora* (Sw.) Kr. et Urb. valde affinis, sed ille a specie nostra, foliis majoribus 2–5 cm longis et 1–2 cm latis, nervis lateralibus supra obsoletis v. nullis, inflorescentiis 5–11-floris, calycis saepe pilosis vel hirsutis, filamentis usque supra medium in columnam connatis glabris differt.

Obs. II.: Hanc speciem in honorem RICHARDIS A. HOWARDI, professoris Universitatis Harvardi atque directoris Arboreti Arnoldi, in cognitione et explorationibus florum Indiae Occidentalis excellentissimi dedicavi.

85. *Scolosanthus liogieri* Borhidi spec. nova (Fig. 5.)

Frutex sarmentosus, spinosusque, usque ad 5–6 m altus (ex ALAIN in schaedis). Rami hornotini veterioresque teretes, pilis basi dilatatis granuloso-scabrosi in nodis spinas bi- vel trifurcatas, recurvas, 8–20 mm longas gerentes. Stipulae interpetiolares in annulum 1–1,5 mm longum, truncatum, superne fimbriatum connatae, demum dehiscenti bilobatae.

Folia 1–1,5 mm longe petiolata, late elliptica vel obovata, antice brevissime apiculata et mucronulato-acuta, vel rotundata, basi obtusa vel late angustata 4–15 mm longa et 3–10 mm lata, nervo medio utrinque nullis; lamina supra viridis lucida, subtus pallidior vel flavescens, nitida, margine revoluta coriacea.

Flores axillares 1–3, fasciculati, 1–1,5 mm longe pedicellati, 4-meri. Calyx 3–4 mm longus, tubus calycis, cum hypanthio, 2,5–3 mm longus, leviter compressus, lobi 0,7–1 mm longi, triangulares, acuti, essentialiter glabri. Corolla 7–9 mm longa, pallide, flava, vel alba e tubo angusto calyciformiter dilatata, superne 5 mm lata, tubus ipse 6–8 mm longus, lobi 4, 1–1,5 mm longi, ovati apice obtusi vel acuti, in anthesi recurvati. Stamina 4, filamenta corollae basi adnata, inter sese 1 mm longe coalita, pars libera 2,5–3 mm longa, sub dimidio puberula. Antherae oblongo-sagittatae 2 mm longae, in tubo corollae insertae. Stylus cylindricus glaber, 12–13 mm longus, e tubo corollae longe exsertus, apice breviter bilobatus. Ovarium inferum 2-loculare. Fructus inferus, drupaceus, non pleno maturus, viridis, lateraliter compressus, leviter 8-costatus, 7–9 mm longus et 4–5 mm latus, glaber, apice calycibus 1 mm longis coronatus, bispermus.



Fig. 5. *Scolosanthus liogieri* Borhidi sp. n. (delined by Mrs. Gizella GYURKÓ, based on the type specimen). A: habit; B: flower; C: longitudinal section of the corolla; D: fruit

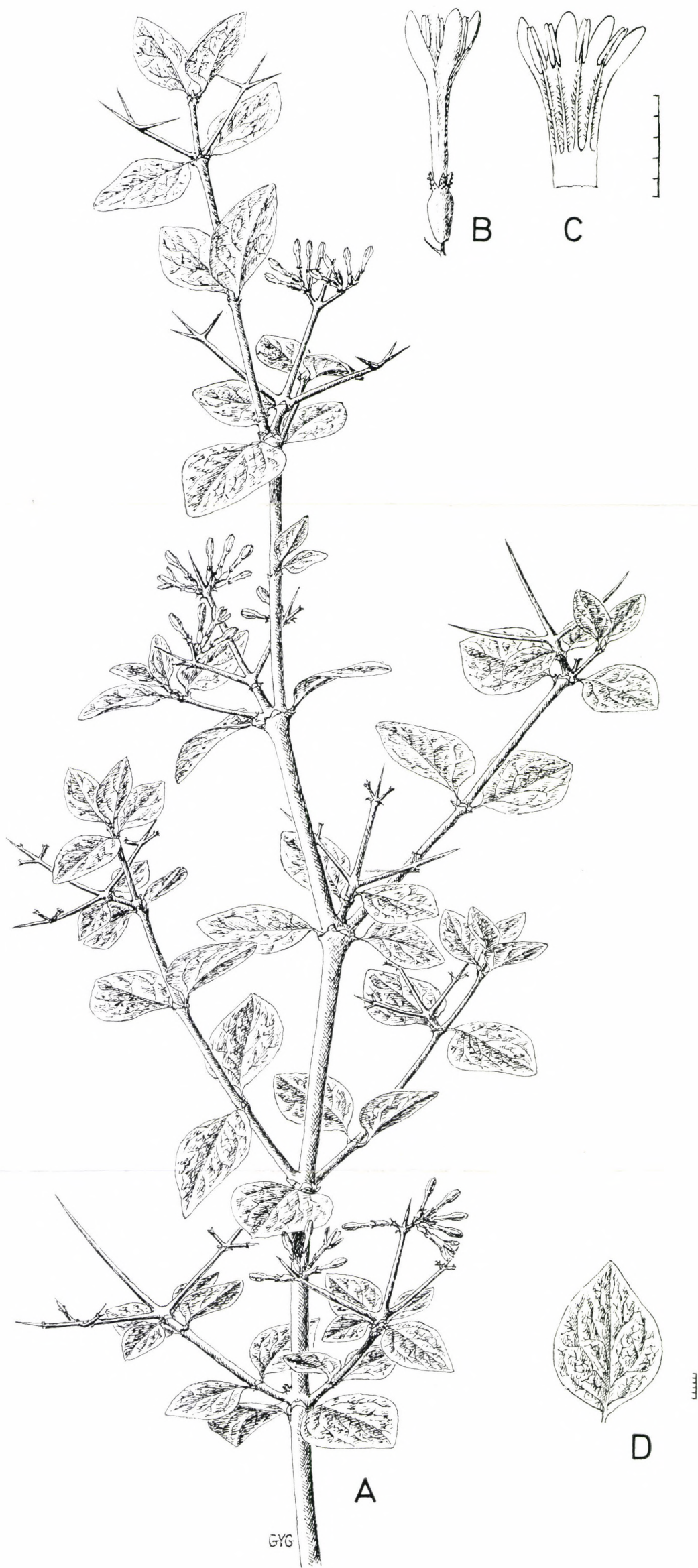


Fig. 6. *Scolosanthus portoricensis* Borhidi sp. n. (delined by Mrs. Gizella GYURKÓ). A: habit; B: flower; C: longitudinal section of the corolla; D: leaf

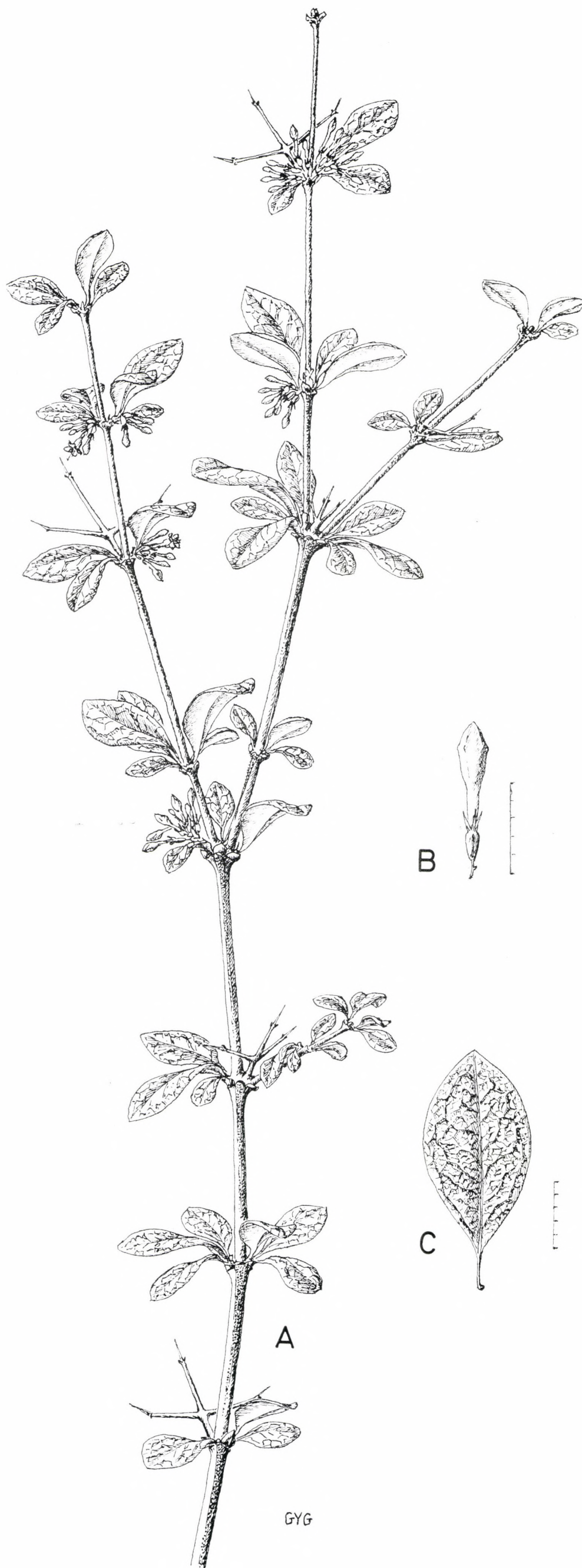


Fig. 7. *Scolosanthus reticulatus* Borhidi sp. n. (delined by Mrs. Gizella GYURKÓ). A: habit; B: flower; C: leaf

Holotypus: ALAIN 16051. Hispaniola, Rep. Dominicana; Loma del Campanario, Ciénaga de la Culata, alt. 1650–1850, in cloud forest. 24. Sept. 1969. NY! **Isotypus:** US!

Specimina examinata: Santo Domingo; Sierra de Neiba, Los Doscientos, Hondo Valle, 1750–1850 m. ALAIN 12504 GH! — Santo Domingo in Mogote Jarabacoa, 1200–1400 m, cloud forest, ALAIN 15775, US! NY! — Santo Domingo, Ciénaga de la Culata, Constanza, pine forest, 1600–1700 m. ALAIN 13010. NY! — Haiti; Massif de la Hotte, western group, Torbec, Mt. Formon, top of limestone ridge, 1500 m. EKMAN H 7437 S! GH!

Obs. I: *Scolosantho grandifolio* Urb. (e Porto Rico) affinis, quae a specie nostra, ramis essentialiter glabris, stipulis basi connatis triangularibus, margine non fimbriatis, foliis lanceolatis vel ellipticis multo majoribus, margine planis abunde differt. Habitu similis altera species *S. selleanus* Urb. et Ekm. a specie nostra spinis rectis, foliis ovatis vel suborbicularibus, corolla purpurascenti, longiori, fructibus minoribus certe aliena.

Obs. II: Hanc speciem in honorem ALAINI H. LIOGIERI exploratoris florum Cubanæ Domingensisque excellentissimi dedicavi.

85. *Scolosanthus moanus* Borhidi et Muñiz spec. nov.

Frutex ramosus, spinosus. Internodii 1,5–2 cm longi. Rami laterales elongati, stricti, erecti, in spinam trifurcatam excurrentes, hornotini dense et minute puberuli, demum sparse resinoso-papilloso, brunnescentes, veteriores crassiusculi. Stipulae interpetiolares ad apicem ramorum tantum visae, in annulum 0,5–1 mm longum, truncatum connatae, demum bilobato-fissae, mox evanescentes. Folia 0,5–2 mm longe petiolata, petiolis margine puberulis vel pilosis suffulta, ovata vel ovato-lanceolata, 12–20 mm longa et 6–12 mm lata, basi obtusa vel angustata, in petiolum protracta, apice acuta vel acuminata, 0,2–0,5 mm longe spinuloso-mucronata, margine integra, revoluta; nervo medio supra paullo, subtus manifeste prominulo, lateralibus utrinque nullis, lamina supra nitida, obscure viridis, in sicco brunnescens, subtus pallidior, resinoso-punctata. Flores ad spinas solitarii, usque ad 0,5 mm longe pedicellati. Calycis tubus obovatus, 1–1,5 mm longus, leviter compressus, glaber; lobi calycis triangulares, 0,5 mm longi, glabri. Cetera non visa.

Holotypus: ACUÑA 13381 SV! Cuba; Prov. Oriente: Breñales de la Playa de Vaca, Moa. Leg.: J. ACUÑA, 9. Nov. 1945.

Obs.: *S. cruciferi* Wr. ex Sauv. affinis, qui a specie nostra foliis apice obtusis vel rotundatis, floribus fasciculatis, lobis calycis semiorbicularibus, margine ciliatis bene differt.

86. *Scolosanthus multiflorus* (Sw.) Kr. et Urb.

ssp. multiflorus:

foliis ellipticis vel lanceolatis, 2–5 cm longis, apice attenuatis et acutis, calyce hypanthioque glabro, 3 mm longo, lobis lanceolatis, acutis, margine glabris, corolla 4,5–6 mm longa, filamenta glabra, parte connata filamentorum partis liberis duplo longiore. Lectotypus: March, 1679; Jamaica GOET; isoelectotypus: GH

ssp. hirticalyx: Borhidi ssp. nova

a typo differt foliis obovatis, apice rotundatis et mucronulatis, 1–2 cm longis, calyce, hypanthioque patenti-hirtulo, 2–2,5 mm longo, lobis ovatis margine ciliatis,

corolla 3–4 mm longa, parte connata filamentorum liberis aequilonga. Holotypus: March, 1716; Jama'ca, GOET.

87. *Scolosanthus nannophyllus* Borhidi spec. nova

Frutex ramosissimus, spinosus. Rami hornotini vix compressi, pilis brevissimis, papilliformibus patentibusque granulato-scabriusculi, in spinam trifurcatam 1–1,5 cm longam excurrentes. Stipulae ad apicem ramorum tantum manifestae, truncatae, vix 0,5 mm longae. Folia dense conferta, 1–1,5 mm longe petiolata, petiolis rubiginosis, glabris suffulta, lamina oblongo-obovata vel oblongo-elliptica, apice obtusa vel rotundata, basi longe cuneata et in petiolum protracta, 3–8 mm longa et 2–5 mm lata, nervis utrinque nullis; supra viridis, nitida, subtus pallidor, papillosa, utrinque glabra, margine valde revoluta, coriacea. Flores in fasciculis foliorum 3–8, 1–2 mm longe pedicellati vel subsessiles. Calycis tubus ovatus, 1–1,5 mm longus, compressus, lobi 4, semiorbiculares, margine glabro, dorso cystolithis punctiformibus obsiti, 0,5–1 mm longi. Corolla 4 mm longa, purpurea, lobi 4, tubus corollae 2,5–3 mm longus in aestivatione imbricati, triangulares 1–1,5 mm longi, reflexi obtusi. Stamina 4, filamenta 2 mm longa, basi in tubo breviter (0,5 mm longe) connata, superne libera, glabra; antherae ellipticae, obtusae, basi obliquae, basifixae. Stylus leviter 4-angularis, apice incrassatus, brevissime bilobus.

Holotypus: Cuba; Prov. Oriente (Guantánamo) manigua de la 2da terraza de Maisi. Leg: LEÓN et MARIE-VICTORIN, No. 17111; 19. Aug. 1939. SV!

Obs.: *S. bahamensi* Britt. affinis, qui foliis supra scabroso-pilosis, petiolis viridibus, calycibus (1 mm) corollisque (2 mm) minoribus, atque calycis lobis pilosis a specie nostra bene differt.

88. *Scolosanthus portoricensis* Borhidi spec. nova (Fig. 6.)

Frutex spinosus, glaber, usque ad 2 m altus. Rami hornotini, subteretes, longitudinaliter striati, nitidi, resinosi, glabri, veteriores teretes, internodiis 2–6 cm longis, in axillis vel in ramis lateralibus spinas trifurcatas vel saepius triternatas 2,5–4 cm longas, gerentes. Stipulae interpetiolares basi in anulum \pm 1 mm longum glabrum, margine membranaceum connatae, superne triangulares 1,5–2 mm longae apice bidentatae mucronatae, demum dehiscenti bilobatae.

Folia sessilia vel usque ad 1 mm longe petiolata, late ovata, sub medio latissima, apice sensim angustata et obtusa vel acutiuscula, basi rotundata, truncata vel breviter angustata, 1,8–3 cm longa et 1,5–2,5 cm lata, nervo medio supra impresso, subtus prominenti, lateralibus utroque latere 2–3 supra impressis subtus prominulis ante marginem arcuato-conjunctis, lamina supra nitidula, viridis, subtus pallide flavicans, nitida, utrinque glabra, margine tenuiter recurva chartacea.

Flores in spinis solitarii vel in fasciculis paucifloris, sessiles vel brevissime pedicellati, 4-meri. Calyx cum hypanthio 2,5–3 mm longus, tubus calycis 2–2,5 mm longus, leviter compressus, lobi 0,7–1 mm longi, triangulares acuti glabri. Corolla 6–7 mm longa, pallide vel albescenti-flava, e tubo superne abrupte dilatata, superne 3–3,5 mm lata, tubus ipse 5–6 mm longus, lobi 1 mm longi, ovati vel triangulares, apice acuti. Stamina 4, filamenta corollae basi adnata, basi inter sese 1 mm longe coalita, pars libera 2,5–3 mm longa, per totam longitudinem puberula. Antherae oblongo sagittatae \pm 2 mm longae, e fauce corollae breviter exsertae. Stylus cylindricus, glaber, apice breviter bilobatus. Ovarium inferum biloculare. Fructus inferus, drupaceus, lateraliter compressus, 4-lobatus, 2-spermus.

Holotypus: ALAIN 9742; Porto Rico; Serpentine barrens of Sosua State Forest in alt. 300–400 m. 26 June 1963. GH.

Specimina examinata: Ibidem ALAIN 9736 US! GH! — Porto Rico; Serpentine soils, Las Mesas, Mayaguez, alt. 300 m. ALAIN 10517 US, GH.

Obs.: *Scolosantho grandifolio* Urb. affinis, sed ab ea ramis rectis non volubilibus, spinis trifurcatis vel triternatis rectis, foliis basi rotundatis vel truncatis, corolla minore, tubo superne sensum ampliato, filamentis per totam longitudinem pilosis, fructibus minoribus differt.

89. *Scolosanthus pycnophyllus* Borhidi spec. nova

Frutex ramosissimus, valde spinosus, usque ad 2 m altus. Rami juniores leviter biangulares, pilis rigidis perbrevis hispidi, veteriores teretes, glabri, omnes in spinas e basi cruciformiter ramificatas, gemmiferas, 1–2 cm longas excurrentes. Folia in axillis fasciculata, 0,5–2 mm longe petiolata, orbicularia, suborbicularia vel late obovata, rari-ter elliptica, 3–8 mm longa et 2–5 mm lata, antice rotundata vel obtusa, basi rotundata, obtusa vel cuneata, nervo medio utrinque nullo vel subtus inferne conspicuo, medio evanescente, laterales utrinque nulli; lamina supra nitida, subtus pallide opaca, coriacea, margine valde revoluta.

Flores axillares uni-pauci, subsessiles vel usque ad 2 mm longe pedicellati. Calyx obovatus usque ad 1 mm longus, levissime compressus, sub lobis leviter contractus, glaber, lobi 4, ovati, apice rotundati, 0,2–0,3 mm longi, glabri. Corolla infundibuliformis, brunneo-lutea 5–6 mm longa glabra. Tubus corollae 4–4,5 mm longus, lobi 4, subcordato-ovatae, antice rotundatae 1,2–1,5 mm longae, sub anthesi valde revolutae. Stamina 4, filamenta 3 mm longa, basi in tubum inter sese connata, inferne pilosula; antherae ellipticae, 1 mm longae, e fauce corollae brevissime exsertae, stylus 5 mm longus, capitato-bilobatus, superne pilosus. Fructus non visus.

Holotypus: 27983 HAC. Cuba; Prov. Holguin (Oriente) Pico Sur del Cerro Galano, entre La Palma y Limones. — Leg.: J. URBINO, 15. Aug. 1975.

Specimina examinata: Holguin; Sabanas La Yaba, LEÓN 15722 HAC, NY; — Holguin; Yareyal, LEÓN 15517 HAC.

90. *Scolosanthus reticulatus* Borhidi spec. nova (Fig. 7.)

Frutex; rami hornotini leviter 4-angulati, faciebus oppositis brevissime pubescentes, cetera glabra, veteriores teretes, glabri, non resinosi, internodiis 1,5–4,5 cm longis, spinis axillaribus simplicibus vel brevissime trifurcatis, 0,5–1,5 cm longis, sparse dispositis armati. Stipulae in vaginam annularem 0,6–1 mm longam, postremo fissam connatae. Folia in axillis fasciculata, 3–6 mm longe petiolata, suborbicularia, oblongo-obovata vel oblanceolata, basi rotundata vel longe attenuata, antice rotundata vel acuta, apice ipso brevissime apiculata et mucronulata, 1–2 cm longa et 0,7–1,7 cm lata; nervo medio supra prominulo, subtus prominenti, lateralibus utroque latere 3–4, supra prominulis et satis dense reticulato-conjunctis, subtus non reticulatis; lamina supra viridis, leviter convexa, subtus carmelitosa, utrinque opaca et glabra, margine tenuiter recurva, chartacea vel subcoriacea.

Flores in fasciculis foliorum 3–8, subsessiles vel 1–1,5 mm longe pedicellati, 4-meri, 10–12 mm longi. Tubus calycis obovatus, glaber, inaequaliter 8-costatus, lateraliter

compressus, 2–3 mm longus, sub lobis leviter contractus; lobi calycis 4, lineares vel lineari-subulati, 1,5–2 mm longi, dorso carinati, superne paullo curvati, margine ciliati. Corolla purpurea, infundibuliformis, 4-mera, acute 4-angulata, utrinque glabra, 8–10 mm longa; lobi 4, triangulares, 1,5–2 mm longi, apice obtusi. Stamina 4, basi corollae inserta; filamenta linearia, 3–3,5 mm longa, pilosula, inferne inter sese connata, superne libera; antherae basi affixae, insertae, lineari-elongatae, 2–3 mm longae, basi leviter obliqueae, apice acutae. Stylus cylindricus, filiformis, 7–8 mm longus, apice in statu juvenili minute globosus, stigma breviter bilobum. Ovarium inferum, 2-loculare. Ovula in quoque loculo solitaria, ab apice loculi pendula, lineari-elongata, 3-angulata, apice ad insertionem albicantem incrassata.

Holotypus: UO 973. Cuba; Prov. Holguín (Oriente): Sierra de Nipe, Salto del Río Guayabo. Leg.: M. LÓPEZ FIGUEIRAS, 27. Mai. 1960. HAC! — Isotypi: BP, HAJB.

Obs. I.: Forma et structura florum atque ovarii *S. multiflora* (Sw.) Kr. et Urb. affinis, sed ab eo et omnibus speciebus aliis his generis, foliis supra reticulato-venosis clare differt.

Obs. II.: Solummodo e collectione typica cognita.

- 90a. **Ottoschmidtia microphylla** (Griseb.) Urb. ssp. **haitiensis** (Urb. et Ekm.) Borhidi **comb et stat. nov.** — Basionymon: *Ottoschmidtia haitiensis* Urb. et Ekm. Ark. Bot. 21A 5: 92 (1928).

Oldenlandia L. and Hedyotis L.

Following the study of H. W. LEWIS (1961), *Oldenlandia* belongs to *Hedyotis* as its subgenus, and the Cuban species of *Oldenlandia* should be known under the following names:

- 90b. **Hedyotis callitrichoides** (Griseb.) W. H. Lewis = *Oldenlandia callitrichoides* Griseb.

91. **Hedyotis capillipes** (Griseb.) W. H. Lewis = *Oldenlandia capillipes* (Griseb.)

92. **Hedyotis lancifolia** K. Schum. = *Oldenlandia lancifolia* (K. Schum.) DC.

93. **Hedyotis maëstrensis** (Alain) Borhidi **comb. nova** = *Oldenlandia maëstrensis* Alain Contrib. Ocas. Mus. Hist. Nat. Col. La Salle 17: 6 (1959).

94. **Hedyotis polyphylla** (Urb.) Borhidi **comb. nova** = *Oldenlandia polyphylla* Urb. Symb. Ant. 9: 148 (1923).

95. **Hedyotis uniflora** DC. = *Oldenlandia uniflora*

Borreria G. F. W. Meyer and Spermacoce L.

Recently the opinion of the taxonomists is distributing that the separation of *Borreria* G. F. W. Meyer from *Spermacoce* L. based upon the dehiscence of the both valves of the capsule of the *Borreria* is artificial, and this genus should be merged into *Spermacoce*. The complete list of the Cuban species is as follows:

96. **Spermacoce assurgens** Ruiz et Pav. = *Borreria laevis* auct. cub. non *Spermacoce laevis* Lam.
97. **Spermacoce confusa** Rendle

98. *Spermacoce eritrichoides* (Wr. in Griseb.) Wr. in Sauv. = *Borreria eritrichoides* Wr. in Griseb.
99. *Spermacoce exasperata* Urb.
100. *Spermacoce matanzasia* (Urb.) Borhidi **comb. nova** — Basionymon: *Borreria matanzasia* Urb. Symb. Ant. 9: 541 (1928).
101. *Spermacoce oligantha* Urb.
102. *Spermacoce repens* (DC.) Fosberg et Powell = *Borreria ocimoides* auct. cub. non *Spermacoce ocimoides* Burm. f.
103. *Spermacoce rubricaulis* Wr. in Sauv. = *Borreria rubricaulis* (Wr. in Sauv.) Urb.
104. *Spermacoce spinosa* L. = *Borreria spinosa* (L.) Cham. et Schlecht.
105. *Spermacoce strumphioides* (Wr. in Griseb.) Wr. in Sauv. = *Borreria strumphioides* Wr. in Griseb.
106. *Spermacoce tenella* H. B. K. = *Borreria suaveolens* Mey.
107. *Spermacoce tenuior* L.
108. *Spermacoce tetraquetra* A. Rich.
109. *Spermacoce thymocephala* (Griseb.) Wr. in Sauv. = *Borreria thymocephala* Griseb.
110. *Spermacoce verticillata* L. = *Borreria verticillata* (L.) Mey.

Compositae

Eupatorium L. s.l.

En los últimos 15 años una revisión taxonómica muy notable ha sido realizado por R. M. KING y H. ROBINSON sobre el tribú Eupatorieae. Un número grande de géneros nuevos separaron y describieron y consecuentemente la taxonomía del tribú se ha modificado grandemente. Para la flora de Cuba describieron dos géneros nuevos (*Antillia* y *Grisebachianthus*) y otro género nuevo mas para Cuba y Jamaica (*Urbananthus*). Ampliaron el género endémico cubano *Spaniopappus*, anteriormente conocido como monotípico, con cinco especies y reagruparon las 55 especies cubanas del *Eupatorium* en 10 géneros siguientes. (Esta parte del artículo esta escrito en español para dar la descripción de los géneros en el idioma de la Flora de Cuba.)

Hebeclinium DC. Prodrumus 5: 136 (1836)

Plantas herbáceas o sufrutices; hojas opuestas, distintamente pecioladas. Inflorescencia una panícula corimbosa. Involucro de 25–40, brácteas lanceoladas en 3–5 series; receptáculo semigloboso, laxa- o densamente peloso; flores 20–80 por capítulos. Corola estrechamente tubulosa, 5-lobulada, la superficie glabra por debajo, lóbulos comunmente mas largos que anchos con pelos multicelulares prominentes uniserialmente dispuestos y con algunas glándulas; pelos multiseptados numerosos por dentro, estomas ausentes. Collar de la antera a menudo delgado, compuesto de células de paredes delgados, sin adorno. Apéndice de la antera bastante grande con células grandes. Estilo glabro, sin nódulo engrosado en la base. Apéndice del estilo muy estrecho por toda su longitud, ligeramente mamiloso. Aquenio prismático, 4–5-surcado, setas a veces presentes. Carpodidio poco distinto, solamente pocas series de células cortas marginales.

Vilano de 30–40 setas escabrosas, células apicales apunteadas. Numero de cromosomas: $x = 10$. 11 especies neotropicales. Especie típica: *Eupatorium macrophyllum* L.

111. **Hebeclinium macrophyllum** (L.) DC. = *Eupatorium macrophyllum* L.

Chromolaena DC. Prodrum 5: 133 (1836)

Plantas herbáceas y arbustos laxa- o densamente ramificados. Hojas opuestas, subenteras a muy lobuladas. Inflorescencia laxa- o densamente corimbosa, capítulos 10–40; brácteas involucrales 18–45, aovadas a lanceoladas, densamente imbricadas, muy desiguales, a veces deciduas, en 4–6 series; receptáculo plano a convexo, glabro, paleas a veces presentes. Corola tubular, con base ligeramente contracta, lampiña por fuera, puntas de los lóbulos cubiertos por un grupo de células de paredes gruesas, prominentes; superficie exterior con algunas glándulas estipitadas y a menudo con pelos bastante rígidos, sin estomas; lóbulos papilosos por dentro con un estrato denso de células sobresalientes; células del tubo de la corola estrechas, con paredes sinuosas, sobresalientes en el extremo superior. Collar de la antera compuesta de células cuadradas por debajo y alargadas por arriba, comunmente con cintas ornamentales prominentes en las paredes transversales en las células largas, oblicuas o verticales en las células cortas. Apéndice de la antera grande, entero y dentado en el ápice. Polen tricolpato, esférico, espinoso. Estilo sin nódulo basal, células superficiales del apéndice estilar lampiñas y largamente salientes. Aquenio prismático 5 o 3-costado, setoso en las costas, a veces con glándulas. Carpogodio brevemente cilíndrico u estrechado por abajo, células pequeñas, a menudo mas anchas que altas, comunmente con paredes engrosadas. Vilano de cca 40 setas delgadas, escabrosas, persistentes, con células apicales apuntadas. Unas 130 especies neotropicales. Especie típica: *Chromolaena horminioides* DC.

112. **Chromolaena odorata** (L.) King et Robins. = *Eupatorium odoratum* L.
 113. **Chromolaena corymbosa** (Aubl.) King et Robins. = *Eupatorium corymbosum* Aubl.
 114. **Chromolaena ivaefolia** (L.) King et Robins. = *Eupatorium ivaefolium* L.
 115. **Chromolaena osseana** (DC.) King et Robins. = *Eupatorium osseanum* DC., no se encuentra en Cuba.
 116. **Chromolaena sinuata** (Lam.) King et Robins. = *Eupatorium sinuatum* Lam.

Critonia P. Browne Civ. Nat. Hist. Jam. 1756. 490.

Yerbas, arbolitos o trepadoras laxamente ramificadas. Hojas opuestas, distintamente pecioladas, peciolo a veces alado, lámina elíptica o anchamente aovada sin glándulas, pero con lacunas lactíferas internas cerca de los nervios o en la mitad de las areolas. Inflorescencia paniculada, ramas extendidas rectangularmente. Capítulos sentados o en fascículos de 3–12. Involucro de cca 25 brácteas imbricadas, mayormente glabras y arregladas en 4–6 series. Brácteas interiores elípticas a estrechamente oblongas, muy caedizas, exteriores muy cortas, orbiculares, persistentes. Receptáculo plano y poco convexo, glabro o con pocos pelos. Flores 4–12 por capítulo. Corola tubular abajo y a veces ligeramente ensanchado arriba, glabra, 5-lobulada. Lóbulos comunmente mas largos que anchos, con células alargadas, lampiñas, de paredes poco sinuosas. Filamentos cortos, insertos sobre el tercio inferior de la corola. Collar de la antera con células cuadradas, distintas abajo, sin adorno o con un ligero engrosamiento anillar; apéndice de la antera grande, comunmente mas largo que ancho. Estilo sin nódulo basal, glabro. Apéndice estilar filiforme a espatulado, lampiño a mamiloso. Aquenio prismático, muy delgado en la base, con 5 costas prominentes, costas y superficie esparcida- a densamente setosas. Carpogodium un canto estrecho o corto, cilíndrico, células pequeñas, cuadradas a redon-

deadas, con abultamientos confluentes. Vilano de 30–35 setas escabrosas, persistentes, con bases repletas, ápices ligeramente ensanchados y serrulados, células apicales agudas. Numero de cromosomas: $x = 10$. Género neotropical de unas 32 especies.

Espécie típica: *Eupatorium dalea* L.

117. *Critonia aromatisans* (DC.) King et Robins. = *Eupatorium aromatisans* DC.
 118. *Critonia dalea* (L.) DC. = *Eupatorium dalea* L.
 119. *Critonia imbricata* Griseb. = *Eupatorium imbricatum* (Griseb.) Urb.
 120. *Critonia pseudo-dalea* DC. = *Eupatorium pseudo-dalea* (DC.) Maza et Mol.

Urbananthus King et Robins. *Phytologia* 21: 54 (1971)

Arbustos laxamente ramificados. Hojas opuestas, pecioladas glabras; laminas elípticas, breve- o largamente acuminadas, células lactíferas no bien conspicuas. Inflorescencias laxamente paniculadas. Brácteas involucrales 20–30 desiguales, 5–8 seriadas, orbiculares u oblongas, glabras, 2–3 estriadas, escamas interiores caedizas. Receptáculo poco convexo. Flores 4–10 per capitulo; corola tubular, glabra células estrechas de paredes muy sinuosas, lóbulos 5, oblongo-triangules. Filamenta inserta en la base de la corola, arriba estrechada, células cuadradas o mas cortas de paredes sin adorno; apéndice de las anteras subcuadradas o mas breves; estilo no noduloso en la base, glabro, apéndices espatulados, oblicuos. Aquenio prismático, 5-costato, glabro. Carpopodio distinto, simétrico, células diminutamente cuadradas abajo, mas largas por arriba de paredes engrosadas. Vilano setiforme, uniseriado, setas de cca 30, contiguas, escabrosas, persistentes, no ensanchadas en el ápice, células apicales agudas. Género de 2 especies, una de Jamaica y otra de Cuba.

Espécie típica: *Eupatorium critoniforme* Urb.

121. *Urbananthus pluriseriatus* (B. L. Robins.) King et Robins. = *Eupatorium pluriseriatum* B. L. Robins.

Grisebachianthus King et Robins. *Phytologia* 32 (3): 268 (1975)

Plantas fruticosas, poco ramificadas. Tallos cilindricos, tomentosos. Hojas opuestas, glánduloso-punteadas y densamente tomentosas o vellosas en el envés, mayormente trinervias. Inflorescencia corimboso-paniculada, ramitas inferiores opuestas. Capítulos irregularmente dispuestos; escamas involucrales subimbricadas, 4–5-seriadas, por parte deciduas, tomentosas o vellosas y glandulosas. Receptáculo plano y glabro, flores 12–60. Corola embudada, células alargadas, paredes sinuosas, lóbulos mas largos que anchos, glandulosos por el exterior. Filamentos distintos en la parte superior; células inferiores subcuadradas, sus paredes ligeramente ornamentadas, células exotheciales subcuadradas, las de las apéndices de las anteras aovadas o mas cortas. Estilo glabro por abajo, no noduloso en la base, apéndices del estilo estrechamente lineares, brevemente papilosos, clavados en el ápice. Aquenios prismáticos, 5-costados, esparcidamente setulosos y glándulosos por arriba. Carpopodio brevemente cilindrico, células superficiales distintas, subcuadradas, pequeñas, 8–10-seriadas; setas de vilano 20–30, uniseriadas o subbiseriadas, escabridas, ligeramente engrosadas por arriba, células apicales subagudas. Grano de polen 18–20 μ de diámetro, diminutamente espinulosa. Género endémico cubano con 8 especies.

Especie típica: *Eupatorium plucheoides* Griseb.

Los autores citados dieron la clave siguiente para la determinación de las especies:

- 1 a Hojas con peciolo de 5–10 mm de largo 1. *G. carsticola*
 b Hojas subsentadas, peciolo comunmente mas corto de 5 mm 2

- 2 a Capitulos con 30–60 flores 3
- b Capitulos con 10–27 flores 5
- 3 a Apéndice de la antera mitad largo de su anchura a menudo fuertemente bilobado; hojas pinnatinervias mayormente 2. *G. libanoticus*
- b Apéndice de la antera tan largo que ancho, ligeramente bilobado; hojas por lo comun 3-nervias desde la base 4
- 4 a Tallo y envés de las hojas parduzco-tomentosos, nervios no densamente reticulados en el envés, capitulos con 36–60 flores 3. *G. plucheoides*
- b Tallo y envés de las hojas blanco-tomentosos, nervios densos y prominentemente reticulados en el envés, capitulos con 30–40 flores 4. *G. hypoleucus*
- 5 a Hojas brevemente tomentosas en el envés, capitulos con 10–12 flores ... 5. *G. nipensis*
- b Hojas densamente tomentosas en el envés; capitulos con 12–27 flores 6
- 6 a Tallo y envés de las hojas parduzco-tomentosos, hojas anchamente aovadas a aovado-elípticas; brácteas involucrales mayormente obtusas 6. *G. lantanifolius*
- b Tallo y envés de las hojas blanco-tomentosos, hojas aovadas a aovado-oblongas; brácteas involucrales mayormente agudas 7
- 7 a Hojas ásperas al tacto en el haz 7. *G. mayarensis*
- b Hojas lampiñas y lustrosas en el haz 8. *G. holguinensis*

- 122. *Grisebachianthus carsticola* (Borhidi et Muñiz) King et Robins. = *Eupatorium carsticola* Borhidi et Muñiz
- 123. *Grisebachianthus holguinensis* (B. L. Robins.) King et Robins. = *Eupatorium holguinense* B. L. Robins. — En la descripción original el nombre específico de esta especie fue descrita erróneamente, como “*holquinensis*”, mientras el nombre fue basado en el nombre de la localidad de la colecta, que es la ciudad Holguin. En esta forma el nombre específico de esta especie correctamente es: *holguinensis*.
- 124. *Grisebachianthus hypoleucus* (Griseb.) King et Robins. = *Eupatorium hypoleucum* Griseb.
- 125. *Grisebachianthus lantanifolius* (Griseb.) King et Robins. = *Eupatorium lantanifolium* Griseb.
- 126. *Grisebachianthus libanoticus* (Sch.-Bip.) King et Robins. = *Eupatorium libanoticum* Sch.-Bip. — *Eupatorium reticulatum* A. Rich. non Desv.
- 127. *Grisebachianthus mayarensis* (Alain) King et Robins. = *Eupatorium mayarense* Alain
- 128. *Grisebachianthus nipensis* (B. L. Robins.) King et Robins. = *Eupatorium nipense* B. L. Robins.
- 129. *Grisebachianthus plucheoides* (Griseb.) King et Robins. = *Eupatorium plucheoides* Griseb.

Spaniopappus B. L. Robins. Contr. Gray Herb. n.s. 77: 45 (1926)

Plantas herbáceas o sufrutices laxamente ramificados. Hojas opuestas, peciolo delgados a veces estrechamente alados. Inflorescencia ancha y laxamente corimbosa. Capitulos de 15–70-floros. Involucro de cca 15 brácteas estrechas subimbricadas en 2–3 series. Receptáculo esencialmente glabro. Flores de 5–10 mm de largos. Corola tubular, superficie exterior y margen de los lóbulos papilosos con células fuertemente sobresalientes, sin pelos y glándulas, sin estomas. La superficie interior de los lóbulos densamente papilosos con células agrupadas sobresalientes; células del tubo de la corola estrechas con paredes sinuosas. Collar de la antera con células cuadradas numerosas abajo, alargadas por arriba, con o sin adornos pequeños en la pared; células exotheciales cuadradas o ligeramente mas largas que anchas; apéndice de la antera grande; polen esférica, 3-colpata, espinosa. Base del estilo glabro, no abultado o muy ligeramente; células del apéndice laxamente hinchadas a casi lampiñas. Aquénio prismático, comun-

mente 5-costado, glabro o con algunos pelos. Carpopodio distinto pero no claramente limitado por arriba, con algunas filas de células cuadradas grandes de paredes tenues. Vilano de cca 40 setas delgadas, — en la especie típica solamente algunos pelos cortos, — con células apicales apuntadas. Género endémico cubano con 5 especies.

Especie típica: *Spaniopappus ekmanii* B. L. Robins.

130. *Spaniopappus bucheri* (B. L. Robins.) King et Robins. = *Eupatorium bucheri* B. L., Robins. corr. — Publicado originalmente con un error tipográfico, como *E. "ruckeri"* a pesar de que la planta fue nombrada al honor de su colector G. C. BUCHER.
131. *Spaniopappus ekmanii* B. L. Robins.
132. *Spaniopappus hygrophilus* (Alain) King et Robins. = *Eupatorium hygrophilum* Alain
133. *Spaniopappus iodostylus* (B. L. Robins.) King et Robins. = *Eupatorium iodostylum* B. L. Robins.
134. *Spaniopappus shaferi* (B. L. Robins.) King et Robins. = *Eupatorium shaferi* B. L. Robins.

Antillia King et Robins. *Phytologia* 21: 398 (1971)

Plantas herbáceas perennes. Hojas opuestas. Inflorescencia escaposa, laxa, poco ramificada. Brácteas involucrales cca 25, mayormente oblongas, desiguales, 2-3-seriadas. Receptáculo ligeramente convexo, glabro. Flores 40-50 por capitulos. Corola embudada, 5-lobulada, glandulosa arriba y por el medio y poco setosa por fuera, células exteriores oblongas, paredes ligeramente sinuosas; lóbulos triangulares equilaterales, glabros por dentro, sin estomas, líneas vasculares prolongadas en los lóbulos. Filamentos angustatos por arriba, células rectangulares o cuadradas por debajo de paredes ligeramente nodulosas. Apéndices de las anteras anchamente triangulares, truncados. Estilo no noduloso, glabro en la base, apéndices estrechamente clavados, mamilosos hacia el ápice. Aquenio prismático, 7-8-costato, setífero. Carpopodio distinto, células cuadradas de paredes tenues o engrosadas. Vilano de escamas profundamente laciniadas, persistentes, células marginales agudas. Género endémico, monotípico cubano.

Especie típica: *Eupatorium brachychaetum* B. L. Robins.

135. *Antillia brachychaeta* (B. L. Robins.) King et Robins. = *Eupatorium brachychaetum* B. L. Robins.

Koanophyllon Arruda ex King et Robins. *Phytologia* 22 (3): 149 (1971)

Koanophyllon esta caracterizado por tener inflorescencias piramidalmente paniculadas o corimbosas, las hojas opuestas, involucro y corola glanduloso-punteados. Base del tubo de la corola anchamente tubulosa, los nectarios comunmente grandes, extendidos hacia arriba adentro de la base de la corola. Lóbulos de la corola no pelosos o con pelos muy pocos. Paredes de las células del collar de las anteras no ornamentadas o muy poco. Base del estilo delgado y lampiño, ápice del estilo comunmente clavado. Carpopodio con células pequeñas de paredes ligeramente engrosadas. Vilano persistente con setas a menudo engordadas. Género neotrópico con unas 110 especies y un centro de evolución en las Antillas Mayores.

Especie típica: *Koanophyllon tinctorium* Arruda

136. *Koanophyllon atroglandulosum* (Alain) King et Robins. = *Eupatorium atroglandulosum* Alain
137. *Koanophyllon ayapanoides* (Griseb.) King et Robins. = *Eupatorium ayapanoides* Griseb.
138. *Koanophyllon breviflorum* (Alain) King et Robins. = *Eupatorium breviflorum* Alain
139. *Koanophyllon bullescens* (B. L. Robins.) King et Robins. = *Eupatorium bullescens* B. L. Robins.

140. **Koanophyllon chalconeoides** (B. L. Robins.) King et Robins. = *Eupatorium chalconeoides* B. L. Robins.
141. **Koanophyllon clementis** (Alain) King et Robins. = *Eupatorium clementis* Alain
142. **Koanophyllon ekmanii** (B. L. Robins.) King et Robins. = *Eupatorium ekmanii* B. L. Robins.
143. **Koanophyllon grandiceps** (W. in Sauv.) King et Robins. = *Eupatorium grandiceps* W. in Sauv.
144. **Koanophyllon grisebachianum** (Alain) King et Robins. = *Eupatorium grisebachianum* Alain — *Eupatorium incisum* Griseb. non L. C. Rich.
145. **Koanophyllon gundlachii** (Urb.) King et Robins. = *Eupatorium gundlachii* Urb. — *Eupatorium muricatum* Alain
146. **Koanophyllon helianthemoides** (B. L. Robins.) King et Robins. = *Eupatorium helianthemoides* B. L. Robins.
147. **Koanophyllon littorale** King et Robins. nom. nov. = *Eupatorium littorale* Alain non Cabrera
148. **Koanophyllon maestrense** (Urb.) King et Robins. = *Eupatorium maestrense* Urb.
149. **Koanophyllon minutifolium** (Alain) King et Robins. = *Eupatorium minutifolium* Alain
150. **Koanophyllon nudiflorum** (A. Rich.) King et Robins. = *Eupatorium nudiflorum* A. Rich.
151. **Koanophyllon oligadenium** (Alain) King et Robins. = *Eupatorium oligadenium* Alain
152. **Koanophyllon polystictum** (Urb.) King et Robins. = *Eupatorium polystictum* Urb.
153. **Koanophyllon prinodes** (B. L. Robins.) King et Robins. = *Eupatorium prinodes* B. L. Robins.
154. **Koanophyllon rhexioides** (B. L. Robins.) King et Robins. = *Eupatorium rhexioides* B. L. Robins.
155. **Koanophyllon silvaticum** (B. L. Robins.) King et Robins. = *Eupatorium silvaticum* B. L. Robins.
156. **Koanophyllon turquinense** (Alain) Borhidi **comb. nova** = *Eupatorium turquinense* Alain Contr. Ocas. Mus. Hist. Nat. Col. La Salle 18: 7 (1960)
157. **Koanophyllon villosum** (Sw.) King et Robins. = *Eupatorium villosum* Sw.
 — ssp. **villosum**
 — ssp. **cubense** (DC.) Borhidi **stat. nov.** = *Eupatorium cubense* DC. Prodr. 5: 172 (1836). — *Koanophyllon cubense* King et Robins. Phytologia 32 (3): 256 (1975)
 — ssp. **cynanchifolium** (DC.) Borhidi **stat. nov.** = *Eupatorium cynanchifolium* DC. Prodr. 5: 172 (1836). — *Koanophyllon cynanchifolium* King et Robins. Phytologia 32 (3): 256 (1975)
 — ssp. **lindenianum** (A. Rich.) Borhidi **stat. nov.** = *Eupatorium lindenianum* A. Rich. in Sagra Hist. Fis. Pol. Nat. Cuba XI: 42 (1850). — *Koanophyllon lindenianum* King et Robins. Phytol. 32: 260 (1975)

Conoclinium DC. Prodr. 5: 135 (1836)

158. **Conoclinium coelestinum** (L.) DC. = *Eupatorium coelestinum* L.

Ageratina Spach, Hist. Veg. Phanerog. 10: 286 (1841)

Plantas herbáceas o arbustos con hojas opuestas, a veces subopuestas o alternas, deltoideas o elípticas, breve- o largamente pecioladas, el margen dentado o lobado,

mayormente serrulado. Inflorescencia corimbosa; capítulos de 10–40-flores; involucreo de cca 30 estrechas, mayormente agudas subimbricadas y subiguales brácteas en 1–2(3) series; receptáculo glabro o a veces con algunos pelos esparcidos. Corola tubular o a menudo con una base larga y muy estrecha continuando en un limbo abruptamente dilatado. Superficie exterior de los lóbulos lampiña, a menudo con células hinchadas o prominentes en el ápice, con pelos y/o glándulas, a glabros, sin estomas; la superficie interior papiloso con un estrato denso de células hinchadas cortas o de prominentes largas; células del tubo mayormente estrechos con paredes sinuosos. Collar de la antera compuesta de células cuadradas por abajo y alargadas por arriba, todos sin adorno notable. Apéndice de la antera largo, a menudo truncado en el ápice. Polen esférico, tricolpato, espinoso. Estilo mayormente con un nódulo glabro en la base, a menudo marcado por células especiales de paredes firmes; apéndice estilar cubierto por células largamente prominentes, densas. Aquenio prismático generalmente 5-costado, con setas, o glándulas o ambos. Carpopodio distinto pero sin límite marcado por arriba, cilíndrico o redondeado con células cuadradas o alargadas, de paredes tenues, perladas. Vilano de 5–40 setas escabrosas mayormente deciduas por una zona fragil especializada en la base; células apicales apuntadas. Numeros de cromosomas muy variados: $n = 17, 18$, cca 40; $2n = 34, 36, 48, 51$, cca 80. Género pantropical dividida en 4 subgéneros y con unas 200 especies.

Especie típica: *Eupatorium aromaticum* L.

Subgénero: **Ageratina**

Plantas herbáceas, corola muy estrecha en la base, generalmente con pelos en el dorso de los lóbulos, raramente con algunos largamente estipitados, o glabros; células de la superficie interior de la corola y en el apéndice estilar largamente prominentes. Aquenios sin glándulas. Carpopodio cilíndrico con células mayormente alargadas. Setas de vilano muy caedizas. Unas 80 especies, 2 de Cuba.

159. *Ageratina corylifolia* (Griseb.) King et Robins. = *Eupatorium corylifolium* Griseb.

160. *Ageratina riparia* (Regel) King et Robins. = *Eupatorium riparium* Regel

Subgénero: **Klattiella** King et Robins. Phytol. 19: 218 (1970)

Plantas suffrutescentes; corola extremadamente angustata por abajo, la parte angustata pubescente; lóbulos igual largos o mas que la garganta, glandulosos por fuera, y ancha- y oscuramente papilosos por dentro. Apéndice del estilo muy papiloso. Aquenio glanduloso y setoso, carpopodio corto y redondeado con células cuadradas u oblongas, setas de vilano mas o menos persistentes. 2 especies, una de Costa Rica y una de Cuba.

Especie típica: *Eupatorium anisochroma* Klatt

161. *Ageratina paucibracteata* (Alain) King et Robins. = *Eupatorium paucibracteatum* Alain

Subgénero: **Neoreenella** King et Robins. Phytol. 19: 218 (1970)

Plantas herbáceas o frutescentes; corola mayormente no angustata en la base, lóbulos mas cortos que la garganta, glandulosos, pelosos o glabros por fuera, densa- o laxamente papilosos por dentro. Apéndice del estilo mayormente muy papiloso; aquenio glanduloso o setuloso; carpopodio brevemente redondeado, células mayormente cuadradas. Setas de vilano mas o menos persistentes. Unas 113 especies neotropicales, 2 de ellas cubanas. Especie típica: *Eupatorium wrightii* A. Gray

162. *Ageratina havanensis* (H. B. K.) King et Robins. = *Eupatorium havanense* H. B. K.

163. *Ageratina mortoniana* (Alain) King et Robins. = *Eupatorium* × *mortonianum* Alain

Isocarpha R. Br.

A new systematic study published by D. J. KEIL and T. F. STUESSY [Systematic Botany 6: 258–287 (1981)] suggests the following taxonomic changes for the Cuban taxa of this genus:

Isocarpha cubana Blake = *I. atriplicifolia* (L.) R. Br. var. *wrightii* Griseb.

Isocarpha glabrata Blake = *I. oppositifolia* (L.) Cass.

In my systematic concept — explained in the preface of this article — the treated taxa could be more consequently recognized as follows:

164. **Isocarpha atriplicifolia** (L.) R. Br. ex DC.

— ssp. **atriplicifolia** — Central America–Venezuela

— ssp. **billbergiana** (Less. in Schlecht et Cham.) Borhidi **stat. nov.** — Basionymon: *Isocarpha billbergiana* Less. in Schlecht. et Cham. Linnaea 6: 405 (1831). Syn.: *I. atriplicifolia* var. *billbergiana* Keil et Stuessy. Syst. Bot. 6: 271 (1981) — Colombia, Venezuela, Trinidad.

— ssp. **wrightii** (Griseb.) Borhidi **stat. nov.** — Basionymon: *Isocarpha atriplicifolia* (L.) R. Br. ex DC. var. *wrightii* Griseb. Cat. Plant. Cub. 1866: 156 — Cuba, Hispaniola.

165. **Isocarpha oppositifolia** (L.) Cass.

— ssp. **oppositifolia** — Texas, Bahamas, Antilles, NE-Venezuela.

— var. **oppositifolia**

— var. **glabrata** (S. F. Blake) Borhidi **comb. et stat. nov.** — Basionymon: *Isocarpha glabrata* S. F. Blake Contr. U. S. Natl. Herb. 22: 614 (1924).

— ssp. **achyranthes** (DC.) Borhidi **stat. nov.** — Basionymon: *Dunantia achyranthes* DC. Prodr. 5: 627 (1836). — Syn.: *I. oppositifolia* var. *achyranthes* (DC.) Keil et Stuessy Syst. Bot. 6: 280 (1981). — Mexico, Central America, Colombia, Venezuela, Trinidad–Tobago, Nederl., Antilles.

Spilanthes L.

According to the taxonomic revision made by R. K. JANSEN [Systematic Botany 6: 231–257 (1981)] the following changes due to the Flora of Cuba:

166. **Spilanthes urens** Jacq. is the only species of this genus occurring in Cuba.

167. **Salmea insipida** (Jacq.) Bolick et Jansen = *Spilanthes insipida* Jacq.

168. **Salmea montana** (Britt. et Blake) Bolick et Jansen = *Spilanthes montana* Britt. et Blake

169. **Salmea pauciceps** Griseb. = *Spilanthes pauciceps* (Griseb.) Blake

Other species of *Spilanthes* published in the Flora of Cuba [ALAIN H. LIOGIER: Flora de Cuba 5: 204–205 (1962)] belong to the genus *Acmella*.

Lachnorhiza A. Rich.

Este género monotípico cubano tiene una variabilidad infraespecífica notable que permite distinguir varios taxones dentro de la especie, como sigue:

Clave analítica para las subespecies de la *Lachnorhiza piloselloides* A. Rich.

- 1 a Hojas lineales o lineal-oblongolanceoladas de hasta 1,3 cm de ancho, carnosas, agudas en el ápice, a veces denticuladas en el margen, nervios laterales mayormente inconspicuos ... 2. ssp. *stenophylla*
- b Hojas obovadas a lineal-obovadas, oblongo-obovadas a espatuladas de 8–30 mm de ancho, obtusas en el ápice el margen no denticulado; nervios laterales conspicuos a prominulos en el envés 2
- 2 a Brácteas interiores 8–14 por capitulo, de 8–10 mm de largo, corola 8–9 mm de largo, capitulos de 1,3–2,2 cm de diámetro 1. ssp. *piloselloides*
- b Brácteas interiores 3–6 por capitulo, de 5–6 mm de largo, corola 5–6,5 mm de largo, capitulos de hasta 1,2 cm de diámetro 3. ssp. *micrantha*

170. Lachnorhiza piloselloides A. Rich.— ssp. *piloselloides*

Foliis membranaceis obovatis, lineari-obovatis, oblongo-ovatis vel oblongo-spathulatis, apice plerumque obtusis, 8–30 mm latis, nervo medio tenui, lateralibus utrinque conspicuis, margine integris; capitulis 13–20 mm in diametro, bracteis involucralis interioribus 8–14 per capita, 8–10 mm longis corolla 8–9 mm longa.

— ssp. *stenophylla* Borhidi ssp. *nova*

Foliis carnosis, in sicco nigrescentibus, lineari-oblongolanceolatis, 5–13 mm latis, apice acutis, nervo medio crassiuscule prominenti, lateralibus plerumque inconspicuis, margine remote glanduloso-denticulatis vel integris, inflorescentiis corollaeque typo similibus.

Holotypus: LEÓN 22863 HAC; Cuba, Pinar del Rio, Laguna Santa Maria, San Luis. Leg.: LEÓN et ALAIN 29. 11. 1948. — Isotypus: ACUÑA 15307. Leg.: ACUÑA, MOLDENKE, LEÓN y ALAIN; HAC.

Specimina examinata: LEÓN 17517 HAC; Isla de Pinos, Sabana de los Indios. Leg.: LEÓN y SEIFRIZ 7. 2. 1940.

— var. *stenophylla*

foliis margine glanduloso-denticulatis, nervis lateralibus nullis.

— var. *dubia* Borhidi var. *nova*

foliis margine integris vel obscure denticulatis, nervis lateralibus obsoletis.

Holotypus: ALAIN 2591 HAC; Pinar del Rio; Sabanas 13 km de la Coloma, 29. 9. 1952. Isotypus: HAC.

Specimina examinata: ALAIN 3528 Ibidem; — ACUÑA 14955, Pinar del Rio; Jovero, Guane 19. 1. 1948; — Escuela Forestal de Guane, CALZADILLA 90, 12. 9. 1962, HAC.

— *ssp. micrantha* Borhidi *ssp. nova*

Scapus glaber, folia spathulata vel ovata, apice rotundata, capitula usque ad 1,2 cm in diametro, bracteae involucales interiores 3–6 per capitula, 5–6 mm longa, corolla 5–6,5 mm longa.

Holotypus: ALAIN 1697 HAC; Pinar del Rio; Cuabales Oeste de Cajalbana, La Palma, 28. 12 (1950).

Specimina examinata: ACUÑA 15994 HAC; Arroyos de Cajalbana, La Palma, 26. 12 (1950).

ACKNOWLEDGEMENTS

The author is indebted to the directors and keepers of the Herbaria A, BM, BP, F, GH, HAC, HAJB, GOET, K, MICH, MO, NY, S, UPS, US who made loans of specimens available for his use.

REFERENCES

- Adams, C. D. (1972): *Flowering Plants of Jamaica*. 848 pp. Univ. West Indies Mona, Jamaica.
- Alain, H. Liogier (1962): *Flora de Cuba*. Vol. 5. 362 pp. Univ. Puerto Rico, Rio Piedras.
- Bisse, J., Rodriguez, A. F. (1980): Tres nuevas especies del género *Calyptanthus* Sw. *Rev. Jard. Bot. Nac. Univ. Habana* **1** (2–3): 41–51.
- Borhidi, A. (1977): *Tetrazygiopsis*, género nuevo de las Antillas y el género *Tetrazygia* L. C. Rich. (Melastomataceae) en Cuba. *Acta Bot. Acad. Sci. Hung.* **23**: 33–39.
- Borhidi, A. (1977): Melastomataceas Nuevas Cubanas. *Abstracta Bot. Univ. Budapest* **5**: 23–32.
- Borhidi, A. (1982a): Die Entwicklung der Flora der Antillen im Lichte der Kontinentalverschiebungstheorie. *Stapfia* **10**: 235–241.
- Borhidi, A. (1982b): Studies in Rondeletieae (Rubiaceae), III. The genera *Rogiera* and *Arachnothyrs*. *Acta Bot. Acad. Sci. Hung.* **28**: 65–72.
- Borhidi, A., Acuña, J., Muñiz, O. (1973): New plants in Cuba, III. *Acta Bot. Acad. Sci. Hung.* **19**: 37–45.
- Borhidi, A., Fernandez, M. Z. (1982a): Studies in Rondeletieae (Rubiaceae), I. A new genus: *Roigella*. *Acta Bot. Acad. Sci. Hung.* **27**: 309–312.
- Borhidi, A., Fernandez, M. Z. (1982b): Studies in Rondeletieae (Rubiaceae), II. A new genus: *Suberanthus*. *Acta Bot. Acad. Sci. Hung.* **27**: 313–316.
- Borhidi, A., Járαι-Komlódi, M., Moncada, M. (1980): *Acunaeanthus*, a new genus of Rubiaceae. *Acta Bot. Acad. Sci. Hung.* **26**: 277–287.
- Borhidi, A., Kereszty, Z. (1979): New names and new species in the flora of Cuba, resp. Antilles. *Acta Bot. Acad. Sci. Hung.* **25**: 1–37.
- Borhidi, A., Muñiz, O. (1971): New plants in Cuba, I. *Acta Bot. Acad. Sci. Hung.* **17**: 1–36.
- Borhidi, A., Muñiz, O. (1977): Myrtaceae novae Cubanæ, I. *Bot. Közlem.* **64**: 13–21.
- Borhidi, A., Muñiz, O. (1976): Plantas nuevas en Cuba, V. *Acta Bot. Acad. Sci. Hung.* **22**: 295–320.
- Fosberg, F. R. (1976): Revisions in the flora of St. Croix U. S. Virgin Islands. *Rhodora* **78**: 79–119.
- Judd, W. J. (1981): A monograph of *Lyonia* (Ericaceae). *J. Arn. Arb.* **62**: 63–436.
- Keil, D. J., Stuessy, T. F. (1981): A taxonomic revision of the genus *Isocarpha* R. Br. *Syst. Bot.* **6**: 258–287.
- King, R. M., Robinson, H. (1970a): Studies in the Eupatorieae (Compositae). XIX. New combinations in *Ageratina*. *Phytologia* **19**: 208–229.
- King, R. M., Robinson, H. (1970b): Studies in the Eupatorieae (Compositae). XX. New combinations in *Spaniopappus*. *Phytologia* **19**: 303–304.
- King, R. M., Robinson, H. (1970c): Studies in Eupatorieae (Compositae). XXIX. The genus *Chromolaena*. *Phytologia* **20**: 196–209.
- King, R. M., Robinson, H. (1971a): Studies in Eupatorieae (Compositae). XXXVII. The genus *Hebelinium*. *Phytologia* **21**: 298–301.

- King, R. M., Robinson, H. (1971b): Studies in Eupatorieae (Compositae). XLIII. A new genus, *Antillia*. *Phytologia* **21**: 398–399.
- King, R. M., Robinson, H. (1971c): Studies in Eupatorieae (Compositae). XLVIII. The genus *Critonia*. *Phytologia* **22**: 46–51.
- King, R. M., Robinson, H. (1971d): Studies in Eupatorieae (Compositae). L. A new genus, *Urbananthus*. *Phytologia* **22**: 54–55.
- King, R. M., Robinson, H. (1975a): Studies in the Eupatorieae (Compositae). CL. Limits of the genus *Koanophyllon*. *Phytologia* **32**: 252–267.
- King, R. M., Robinson, H. (1975b): Studies in the Eupatorieae (Compositae). CLI. A new genus, *Grisebachianthus*. *Phytologia* **32**: 268–270.
- King, R. M., Robinson, H. (1982): Studies in the Eupatorieae (Compositae). CCVII. Additional new combinations. *Phytologia* **49**: 3–6.
- León, H., Alain, H. (1951–1957): *Flora de Cuba*. Vol. 2., 3., 4., Contrib. Ocas. Mus. Hist. Nat. Col. La Salle No. 10., 12., 16. Habana.
- Lewis, W. H. (1961): Merger of the North American *Houstonia* and *Oldenlandia* under *Hedyotis*. *Rhodora* **63**: 216–223.
- Proctor, G. R. (1982): More additions to the flora of Jamaica. *J. Arn. Arb.* **63**: 199–315.
- Urban, I. (1923–1928): *Symbolae Antillanae*. Vol. 9. 543 pp. Berlin.
- Urban, I. (1927): *Plantae Haitienses et Domingenses novae vel rariores V. a cl. E. L. Ekman 1924–1928 lectae*. *Ark. Bot.* **21A**: No. 5: 1–78.

XYLOTOMIC EXAMINATION OF SOME VENEZUELAN CAPPARIS SPECIES, III

K. BABOS,¹ I. R. BERMUDEZ² and L. J. CUMANA C.²

¹ RESEARCH INSTITUTE FOR THE WOOD INDUSTRY, BUDAPEST, HUNGARY

² BIOLOGICAL DEPARTMENT OF SCIENTIFIC SCHOOL, UNIVERSITY OF ORIENTE,
CUMANA, VENEZUELA

(Received: 10 June 1982)

The exterior morphological, ecological characteristics, habitat, moreover the main anatomical features of the xylem of two Venezuelan *Capparis* species are described, namely: *Capparis verrucosa* Jacq. and *C. tenuisiliqua* Jacq. Based on the pubescence of leaf, bud and pedicel, two different varieties of *Capparis tenuisiliqua* can be separated: "*glabrescens*" and "*pubescens*". Therefore, comparative xylotomic examinations were carried out on three samples of each varieties.

Materials and methods

The blocks made from the wood of diverse *Capparis* species were softened in the 1 : 1 mixture of water and glycerin, in a BRINZER's autoclave, at 1.5-2 atm. After the maceration, transversal, tangential and radial sections were prepared. The sections were dyed with the alcoholic solution of Toluidin blue. The maceration of tissues was made with the SCHULZE method (SÁRKÁNY and SZALAI 1964).

Length of fibres and vessel-element, tangential and radial diameters of vessels, width and height of medullary rays and other characteristics were measured. The minima-maxima values of the anatomical features of each *Capparis* species were calculated from 50-100 measurements. Regarding the two varieties of *C. tenuisiliqua*, each characteristic (height of medullary ray, tangential diameter of medullary ray cells, fibre lengths) was calculated on the basis of 150-300 measurements, using mathematical and statistical methods; frequency, mean value (\bar{x}), standard deviation (S), standard deviation of the mean value ($S\bar{x}$), percentage standard deviation of the mean value ($S\bar{x}\%$) were calculated (SvÁB 1967). Enlarged microphotographs were made on each section.

External morphology and distribution

On the basis of a description made by Prof. Isidro R. BERMUDEZ and Luis J. CUMANA C. (BERMUDEZ and CUMANA 1980). The photographs of vegetation and habitat of the two *Capparis* species have been enclosed in the present paper.

Capparis verrucosa Jacq.

Shrub 0.5-3 m high. Stem glabrous. Leaves; alternate, obovate; plate 3.5-13.5 cm long, ending in an acute apex, submarginated, mucronated, glabrous, coriaceous. Inflorescence racemose, terminal. Flowers hermaphrodite, actionomorphic, 2-5 cm long. Calyx with 4 sepals, imbricated, light green; two of them 3-5 mm, the other two 2-4 mm long. Corolla with 4

contorted white and 1–5 cm long petals (Fig. 1). Stamina numerous (63–64), 1.5–2 cm long. Anther bitheca, 2–3 mm long, above a gynophore; bicarpel, unilocular, pseudo-septum is present. Ovules numerous, placentation parietal, stigma sessile. Fruit capsule bacciform, elongated, cylindrical, dehiscent, 6–7 cm long, rugose or stripped, olivaceous.



Fig. 1. *Capparis verrucosa* Jacq. Leaves and inflorescence. Photo: I. BERMUDEZ-L. CUMANA, Tacal-Edo. Sucre



Fig. 2. *Capparis tenuisiliqua* Jacq. "glabrescens". Leaves and inflorescence. Photo: I. BERMUDEZ-L. CUMANA, Tacal-Edo. Sucre



Fig. 3. *Capparis tenuisiliqua* Jacq. "pubescens". Leaves and inflorescence. Photo: I. BERMUDEZ-L. CUMANÁ, Tacal-Edo. Sucre

Habitat: dry, oligotrophic sandy soil, scattered or in small groups, in half shade. Not very frequent.

Distribution: in State of Sucre, Aragua, Zulia, Miranda, Carabobo, Bolívar Lara, Falcón.

Capparis tenuisiliqua Jacq.

1–2 m high shrub. Glabrous stem. Tomentous buds (covered by trichome) or glabrous. Leaves alternate, obovate; abaxial surface is covered by trichoma or glabrous. Plate 1–8–16 cm long, ending in an obtuse apex, marginated, mucronated. Inflorescence racemose, 2.3–9 cm long. Flowers hermaphrodite, actinomorphic, 2–5 cm long. Calyx with 4 sepals, gamosepalous, valved, 2–25 mm long, yellow. Corolla with 4 contorted petals, white, 5–7 mm long. Stamina (18) 1.5–3 cm long. Anthers bitheca, 2–3 mm long, dehiscence longitudinal. Ovary 1.5–3 cm long, bicarpel, unilocular, pseudo-septum is present. Ovules numerous, placentation parietal, stigma sessile. Fruit lineal, elongated, cylindrical, sub-torulose. Capsule dehiscent, 5–18 cm long, tomentous, yellowish-green.

The varieties "glabrescens" and "pubescens"

Habitat and size of the two varieties are similar. From the morphological differences between the two varieties it should be enhanced the typical tomentose indumentum of the vegetative parts (mainly on stems and leaves) in the "pubescens", as well as the characteristic

absence of tomentum in the "glabrescens". The same difference between the two varieties can be observed in the axe, pedicels and sepals of the inflorescence (Figs 2, 3).

There is no valuable difference between the sizes of the perianth and pistil in the two varieties, as it can be seen from the results of measurements:

	"pubescens"	"glabrescens"
Bract	3.9–4.0 mm	4.8–5.0 mm
Petal	2.0 mm	2.0 mm
Sepal	6.0 mm	6.0 mm
Stamen	1.4–2.2 cm	1.4–2.0 cm
Anther	2.0 mm	2.0 mm
Stigma	4.5 mm	3.5 mm
Gynophore	3.0 cm	2.2–2.3 cm

Individuals of the two varieties are growing in the same site, environment, under the same ecological conditions.

Habitat: in dry, rocky and sandy, oligotrophe soil, scattered or in small groups, in half shade or sunny sites. Not very frequent.

Distribution: in State of Sucre, Lara, Falcón, Esparta, Miranda, Carabobo, Zulia, Aragua.

Wood anatomy

Capparis verrucosa Jacq.

Diffused porous wood. The basic mass of wood is formed by polygonal-shaped fibres with thinner wall and wide lumen. Paratracheal and contact-vasicentric longitudinal parenchyma. Medullary rays one or more cell wide (Fig. 4).

Roundish or oval-shaped tracheae, tangentially flattened within the groups (2–8 members); sizes within the *Capparis* species is moderate, not rarely with mastic material. 30–50–117 tracheae per mm². Tangential diameter 20.70–42.11–66.70 μ m. Radial diameter 20.70–39.83–73.60 μ m. Length of the vessel members 50.60–182.89–349.60 μ m; small alternate bordered pits on their wall. Simple perforation plate.

Medullary rays generally 1–2, rarely 3 cells wide, with heterogeneous structure. Height 46.00–192.74–414.00 μ m. Width up to 11.50–19.78–34.50 μ m. Ray cells frequently contain mastic material, and rarely diamond-shaped calcium oxalate crystal (Figs 5, 6).

Fibres are arranged in radial rows. Diameter up to 9.36–12.54–17.16 μ m. Wall thickness 0.78–1.49–3.12 μ m. Full length 284.00–438.10–710.00 μ m. Tip of the fibres ending in a point.

Diameter of the longitudinal parenchyma cells up to 6.90–11.63–16.10 μ m. Height 18.40–66.33–101.20 μ m.

Capparis tenuisiliqua Jacq. "glabrescens" (A) and "pubescens" (B)

Diffused porous wood. The basic mass of wood is formed by the fibres with thinner wall and wide lumen. Paratracheal, contact-vasicentric longitudinal parenchyma. Medullary rays 1–2 cells wide. There is no annual ring zone, nevertheless the growth zones are well distinguishable by the thicker walled fibres in the 1–2 rows (Figs 7, 8).

Roundish or oval-shaped tracheae, radially flattened. Radial groups consisting of 2–12 members (A) and 2–22 members (B), respectively. Tangential groups consisting of 2–4 members in both A and B. Number of tracheae 45–71–119 per mm² (A) and 56–78–145 per mm² (B),

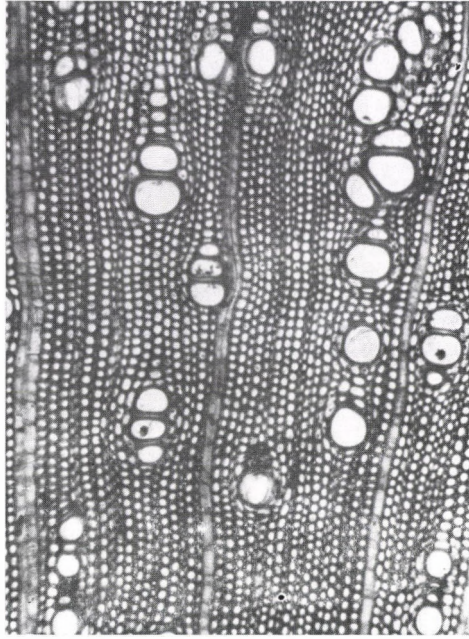


Fig. 4. Capparis verrucosa Jacq. Cross-section. $120\times$. Vessels, groups of vessel with small sized vessel-like tracheids, medullary rays and fibres. Contact vasicentric longitudinal parenchyma



Fig. 5. Capparis verrucosa Jacq. Radial section. $120\times$. Heterogeneous medullary rays, vessels and vessel-like tracheids, longitudinal parenchyma and fibres



Fig. 6. *Capparis verrucosa* Jacq. Tangential section. $120\times$. Medullary rays with one, two and three cells in width, vessel and fibres

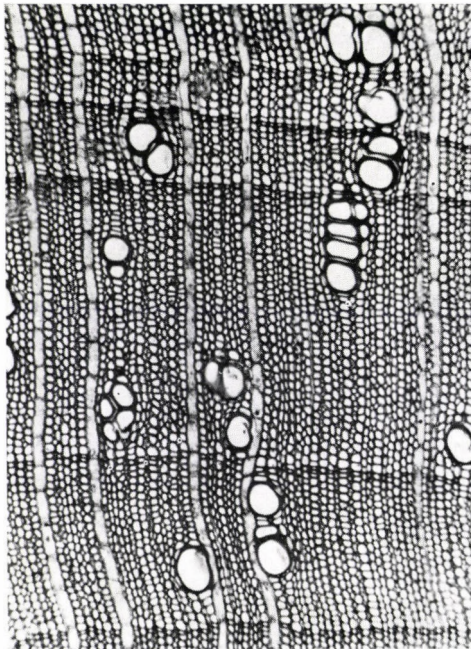


Fig. 7. *Capparis tenuisiliqua* Jacq. "glabrescens". Cross-section. $120\times$. Vessels, groups of vessel with small sized vessel-like tracheids, medullary rays and fibres. Contact vasicentric longitudinal parenchyma. The zones of growth are well visible

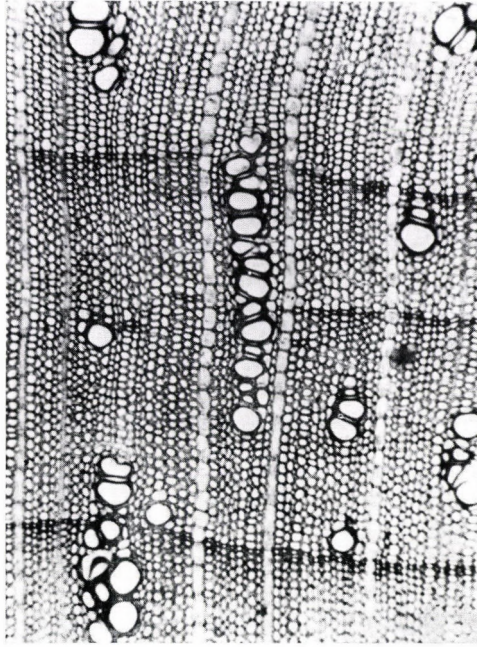


Fig. 8. *Capparis tenuisiliqua* Jacq. "pubescens". Cross-section. $120\times$. Vessels, groups of vessel with small sized vessel-like tracheids, medullary rays and fibres. Contact vasicentric longitudinal parenchyma. The zones of growth are well visible

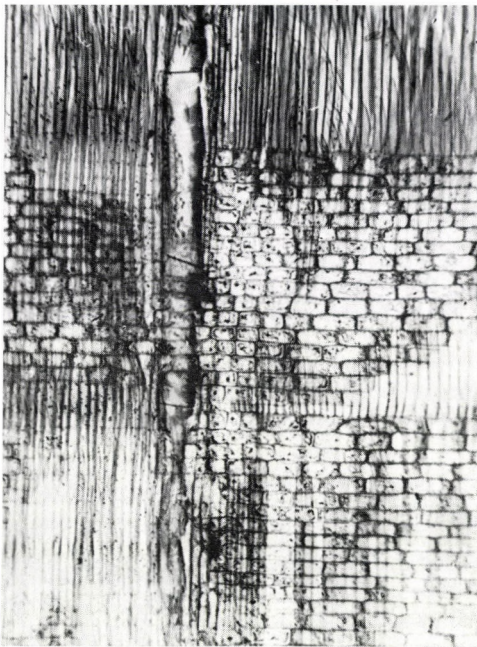


Fig. 9. *Capparis tenuisiliqua* Jacq. "glabrescens". Radial section. $120\times$. High heterogeneous medullary rays and fibres

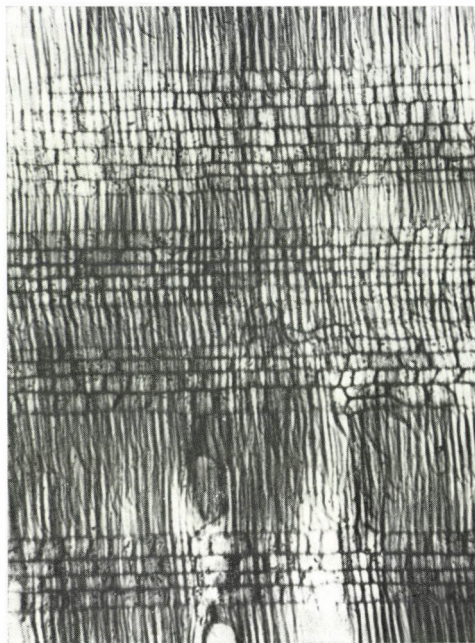


Fig. 10. *Capparis tenuisiliqua* Jacq. "*pubescens*". Radial section. 120 \times . Low heterogeneous medullary rays and fibres

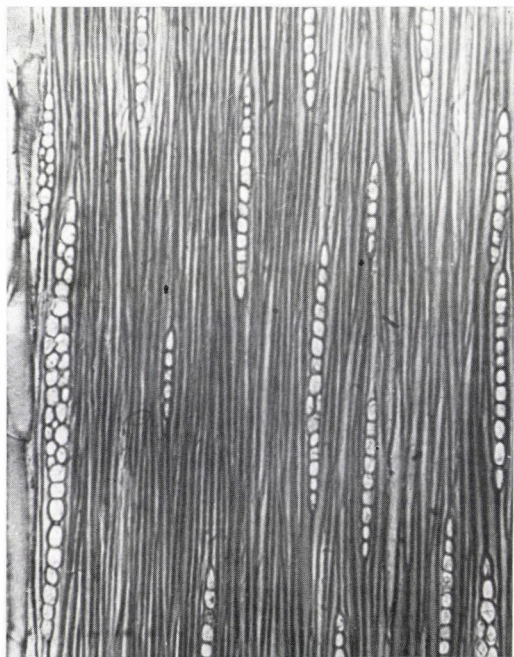


Fig. 11. *Capparis tenuisiliqua* Jacq. "*glabrescens*". Tangential section. 120 \times . Low and high heterogeneous medullary rays with one and two cells in width, vessel and fibres. Size of medullary ray cells: is smaller than that of "*pubescens*"

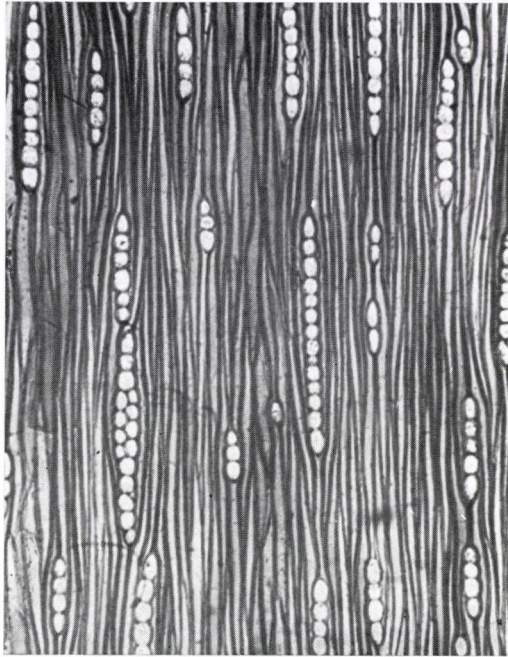


Fig. 12. *Capparis tenuisiliqua* Jacq. "pubescens". Tangential section. $120\times$. Low heterogeneous medullary rays with one and two cells in width and fibres. Size of medullary ray cells is larger than that of "glabrescentis"

respectively. Tangential diameter $20.7\text{--}37.8\text{--}57.5\text{ }\mu\text{m}$ (A), and $16.1\text{--}34.5\text{--}55.2\text{ }\mu\text{m}$ (B), respectively. Radial diameter $11.5\text{--}35.0\text{--}52.9\text{ }\mu\text{m}$ (A), and $16.1\text{--}36.4\text{--}57.5\text{ }\mu\text{m}$ (B), respectively. Length of the vessel members $93.0\text{--}150.4\text{--}218.5\text{ }\mu\text{m}$ (A), and $78.2\text{--}150.6\text{--}211.6\text{ }\mu\text{m}$ (B), respectively. Small, alternate bordered pits on the wall of vessel members. Rarely elongated pits in samples B. Simple perforate plate. Mastic material is not rare.

Medullary rays up to 1–2 cells wide, with heterogeneous structure. Height $46.00\text{--}202.86\text{--}598.00\text{ }\mu\text{m}$ (A), and $34.50\text{--}161.57\text{--}322.00\text{ }\mu\text{m}$ (B), respectively. Width $11.5\text{--}15.9\text{--}23.0\text{ }\mu\text{m}$ (A), and $11.5\text{--}15.4\text{--}23.0\text{ }\mu\text{m}$ (B), respectively. Calcium oxalate crystal is not rare in the medullary ray cells (Figs 9, 10, 11, 12).

Fibres are arranged in radial rows. Diameter $4.6\text{--}11.2\text{--}17.1\text{ }\mu\text{m}$ (A), and $7.8\text{--}11.7\text{--}15.6\text{ }\mu\text{m}$ (B), respectively. Wall thickness $0.78\text{--}1.31\text{--}1.56\text{ }\mu\text{m}$ (A), and $0.78\text{--}1.40\text{--}3.12\text{ }\mu\text{m}$ (B), respectively. Full length $284.0\text{--}403.2\text{--}568.0\text{ }\mu\text{m}$ (A), and $213.0\text{--}378.4\text{--}497.0\text{ }\mu\text{m}$ (B), respectively. Tip of the fibres ending in a point.

Diameter of the longitudinal parenchyma cells $9.3\text{--}11.3\text{--}13.9\text{ }\mu\text{m}$ (A), and $6.9\text{--}9.8\text{--}13.8\text{ }\mu\text{m}$ (B), respectively. Height $79.0\text{--}119.5\text{--}186.0\text{ }\mu\text{m}$ (A), and $69.0\text{--}131.5\text{--}211.6\text{ }\mu\text{m}$ (B), respectively.

The detailed anatomical features of the wood of the two *Capparis* species are summarized in Table 1.

On the basis of measurements carried out on each sample of A and B, differences have been found in the height of medullary ray, as well as in the

Table 1
Anatomical characteristics of the examined species

Wood element	Features	<i>Capparis verrucosa</i>	<i>C. tenuisiliqua</i> (A) "glabrescens"	<i>C. tenuisiliqua</i> (B) "pubescens"
Trachea members	arrangement	diffused, solitary and in groups of 2–8 members	diffused solitary and radial (2–12 memb.), in tangential direction in groups (2–4)	diffused, solitary and radial (2–22 memb.), in tangential direction in groups (2–4)
	shape	roundish or oval-shaped, within the groups tangentially flattened	roundish or flattened in tang. or radial direction	roundish or flattened in tang. or radial direction
	tangential diameter	20.70–42.41–66.70 μm	20.7–37.8–57.5 μm	16.1–34.5–55.2 μm
	radial diameter	20.70–39.83–73.60 μm	11.5–35.0–52.9 μm	16.1–36.4–57.5 μm
	wall thickness	2.30–3.26–6.90 μm	2.3–3.4–5.7 μm	2.3–4.1–9.2 μm
	length of vessel members	50.60–128.89–349.60 μm	93.0–150.4–218.5 μm	78.2–150.6–211.6 μm
	number per mm ²	30–50–117	45–71–119	56–78–145
	intervascular pitting	small, bordered, alternate	alternate, small, bordered	alternate, small, bordered, rarely elongated
Medullary rays	perforate plate content	simple mastic material	simple rarely mastic material	simple rarely mastic material
	width	narrow	narrow	narrow
	number of cells	1–2, rarely 3	1–2	1–2
	classification	heterogeneous	heterogeneous	heterogeneous
	height	46.00–192.74–414.00 μm	46.00–202.86–598.00 μm	34.50–161.57–322.00 μm
	width	11.50–19.78–34.50 μm	11.5–15.9–23.0 μm	11.5–15.4–23.0 μm
Fibres	content	mastic material, rarely diamond-shaped crystal	rarely calcium oxalate crystal	calcium oxalate crystal
	arrangement	in radial rows	in radial rows	in radial rows
	shape	polygonal	polygonal	polygonal
	full diameter	9.36–12.54–17.18 μm	4.6–11.2–17.1 μm	7.8–11.7–15.6 μm
	wall thickness	0.78–1.49–3.12 μm	0.78–1.31–1.56 μm	0.78–1.40–3.12 μm
	full length	284.00–438.10–710.00 μm	284.0–403.2–568.0 μm	213.0–378.4–497.0 μm
Longitudinal parenchyma	type of pitting	small, bordered	small, with split	small, with split
	arrangement	contact, vasicentric	contact, vasicentric	contact, vasicentric
	diameter	6.90–11.63–16.10 μm	9.3–11.3–13.9 μm	6.9–9.8–13.8 μm
	height	18.40–66.33–101.20 μm	79.0–119.5–186.0 μm	69.0–131.5–211.6 μm
	number of cells	2–3	2, rarely 4	1, rarely 2
	content	—	—	—
	other	—	—	—

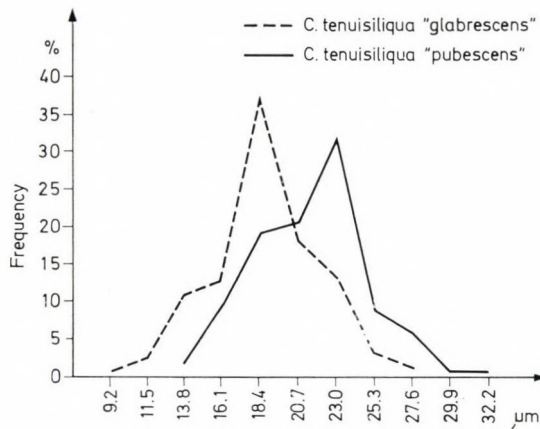


Fig. 13. *Capparis tenuisilqua* Jacq. Frequency percentage of tangential diameters of medullary ray cells in the varieties, graphically illustrated

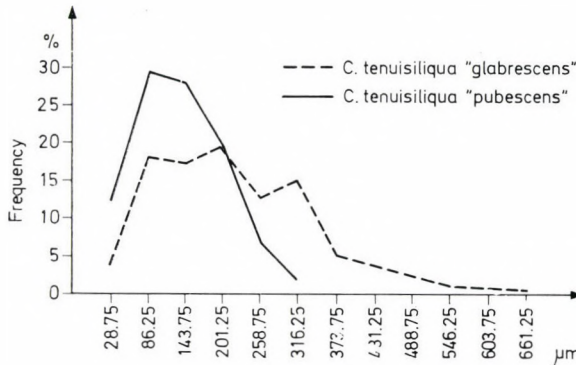


Fig. 14. *Capparis tenuisilqua* Jacq. Frequency percentage of medullary ray heights in the varieties, graphically illustrated

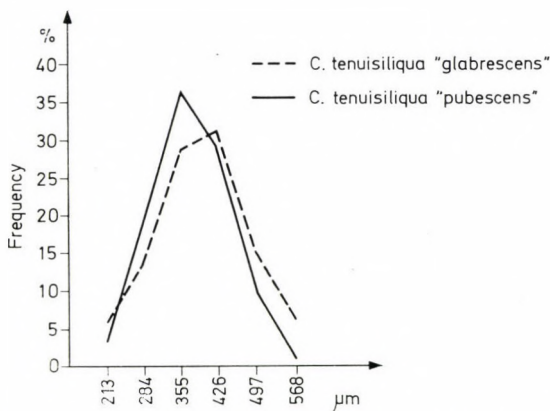


Fig. 15. *Capparis tenuisilqua* Jacq. Frequency percentage of fibre lengths in the varieties, graphically illustrated

fibre lengths. During the microscopic examination of the tangential longitudinal sections of A and B, the different sizes of medullary ray cells were evident (see Figs 11, 12), therefore the cell diameters of another two samples of A and B were measured (mathematically valuable number of measurements: 150 of each samples). According to the results of measurements, the tangential diameter of the medullary ray cells was 9.2–18.7–27.6 μm (A), and 13.8–21.3–32.2 μm (B), respectively. On the basis of the data, the frequency was calculated, and the values were graphically illustrated (Fig. 13). Regarding the height of medullary ray and fibre length, another two samples of both A and B were examined, and 300 measurements were carried out. From the data obtained again the frequency was calculated, which also was graphically illustrated (Figs 14, 15). Statistical data of the three more fully studied features are shown in Table 2.

Table 2

Statistical data of some anatomical features of Capparis tenuisiliqua

Measured features	No. of measurements	<i>C. tenuisiliqua</i> (A) "glabrescens"			
		min. \bar{X} max., μm	$S \pm \mu\text{m}$	$S_x \pm \mu\text{m}$	$S_x\%$
Medullary ray cells, tang. diameter	150	9.2 18.7 27.6	3.34	2.09	11.14
Height of medullary rays, measured in tangential direction	300	57.5 219.0 690.0	121.2	58.84	27.31
Fibre lengths	300	690.0 213 393 568	87.53	54.22	13.78
Measured features	No. of measurements	<i>C. tenuisiliqua</i> (B) "pubescens"			
		min. \bar{X} max., μm	$S \pm \mu\text{m}$	$S_x \pm \mu\text{m}$	$S_x\%$
Medullary ray cells, tang. diameter	150	13.8 21.39 32.2	3.38	2.09	9.77
Height of medullary rays, measured in tangential direction	300	57.5 135.1 345.0	69.47	43.91	32.49
Fibre lengths	300	213 372 568	73.09	54.22	14.57

On the basis of the detailed examinations, it can be concluded that there is a minimal difference between A and B, regarding the fibre length ($A = 393 \mu\text{m}$, $B = 373 \mu\text{m}$). A valuable difference was found between the tangential diameter of the two wood. The most striking difference was found between the height of medullary rays of A and B ($A = 57.5\text{--}219.0\text{--}690.0 \mu\text{m}$, $B = 57.5\text{--}135.1\text{--}345.0 \mu\text{m}$).

It should be noted however, that the results of the examinations carried out so far on the wood of the two varieties have not enabled the two varieties to be separated.

REFERENCES

- Bermudez, I. R., Cumana, L. J. C. (1980): Capparaceae, anatomia del Leño. Manuscript.
Metcalf, C. R., Chalk, L. (1950): *Anatomy of the Dicotyledons*. Vol. I. Caleredon Press, Oxford, 591 pp.
Sárkány, S., Szalai, I. (1964): *Növényyszervezettani Gyakorlatok* (Manual for Praxis of Plant Anatomy). Tankönyvkiadó, Budapest. 559 pp.
Sváb, J. (1967): *Biometriai Módszerek a Mezőgazdasági Kutatásban* (Biometrical Methods in Agricultural Research). Mezőgazdasági Kiadó, Budapest.

CONTRIBUCIÓN AL ESTUDIO ANATÓMICO DEL XILEMA DE LA FAMILIA SIMARUBACEAE EN CUBA, I.

ALVARADOA LIEBM. Y SIMARUBA AUBL.

M. A. VALES y CÁNDIDA MARTINEZ

INSTITUTO DE BOTÁNICA DE LA ACADEMIA DE CIENCIAS DE CUBA, LA HABANA, CUBA

(Recibido: 15 November 1982)

The features of the secondary xylem of the cuban species of the genera *Alvaradoa* and *Simaruba* were described in this paper. The results of this investigation were compared according to the phylogenetic point of view.

Introducción

La familia Simarubaceae comprende aproximadamente 200 especies las cuales se encuentran distribuidas en 32 géneros. La mayoría de las especies de esta familia son plantas lignificadas tropicales y subtropicales, las cuales se caracterizan por poseer mayormente hojas alternas y solo raras veces opuestas, simples o pinnadas y sin estípulas, inflorescencias axilares o terminales en panículas o racimos con flores pequeñas monoicas, dioicas ó hermafroditas.

La historia de las revisiones de este grupo nos muestra que los estudios taxonómicos mas importantes fueron realizados por JADIN (1901), LOESNER y SOLEREDER (1905), HALLIER (1908 y 1923) y ENGLER (1931). Este último autor divide esta familia en 6 subfamilias.

WEBER (1936) describió la anatomía sistemática de las maderas de la familia, sin embargo no se ofrecen en ese trabajo las descripciones detalladas del xilema secundario de cada uno de los táxones por ella investigados.

En el presente trabajo se realizan las descripciones anatómicas de las maderas de *Alvaradoa amorphoides* Liebm. ssp. *psilophylla* (Urb.) Cronquist, *Alvaradoa arborescens* Griseb., *Simaruba glauca* DC. y *Simaruba laevis* Griseb. con el fin de contribuir al Atlas xilotómico de plantas cubanas.

Materiales y metodos

Muestras de maderas de los géneros *Alvaradoa* y *Simaruba* fueron colectadas en el campo con sus correspondientes ejemplares de herbario.

Para el estudio microscópico de los elementos que constituyen el xilema secundario de estas especies, se confeccionaron pequeñas probetas, las cuales previo ablandamiento en agua, fueron seccionadas con un micrótopo de deslizamiento a un grosor de 20-30 μm . Los cortes transversales, longitudinales tangencial y radial fueron deshidratados y aclarados en xylol y montados en portaobjetos con bálsamo del Canadá. Los análisis cuantitativos de los caracteres observados en las secciones se obtuvieron de 50 mediciones para cada caracter. El largo de las fibras, elementos de los vasos y series del parénquima axial se obtuvo de 100, 50 y 30 mediciones respectivamente realizadas en material disregado según FRANKLYN (1946).

Los términos utilizados en las dimensiones y abundancia de los elementos de la madera son los propuestos por CHATTAWAY (1932).

Alvaradoa amorphoides Liebm. ssp. *psilophylla* (Urb.) Cronquist

Esta subespecie presenta una distribución norte-caribeana, creciendo en las Bahamas, Florida y en toda Cuba, en bosques litorales y semidecíduos como un elemento muy frecuente. El ejemplar estudiado se colectó junto a *Clerodendron calcicolum*, *Cordia sebestena* y *Savia sessiliflora* entre otras.

La madera de esta especie se caracteriza por no presentar zonas de crecimiento conspicuas, porosidad difusa, los poros solitarios redondos a ovales; muy frecuentes en múltiplos de 4 o más radiales u oblicuos. Traqueidas vasculares presentes. Las fibrotraqueidas constituyen el elemento mas abundante y se encuentran irregularmente distribuídas en sección transversal (Fig. 1). Frecuentemente se observan fibras septadas formando bandas con contenidos oscuros. Parénquima axial escaso; las series del parénquima formadas por 2 células. Largo de las series 58–94–138 μm . Radios medulares heterogéneos, 1–6 raras veces 7 células

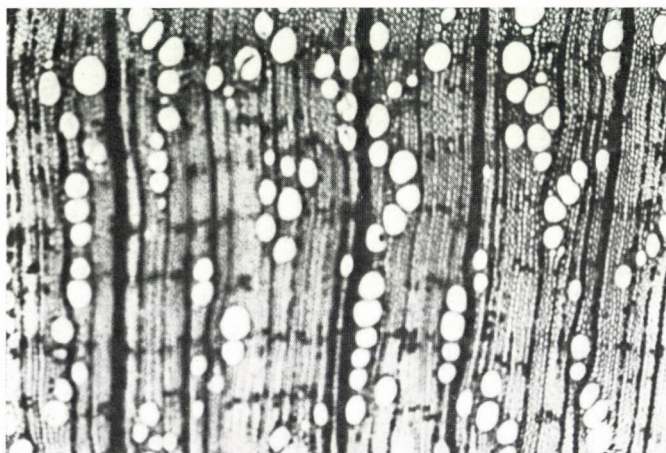


Fig. 1. *A. amorphoides*, corte transversal. 100 \times

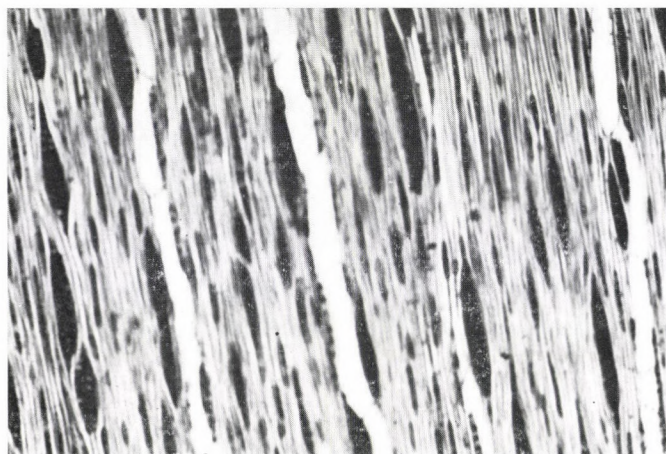


Fig. 2. *A. amorphoides*, corte tangencial. 100 \times

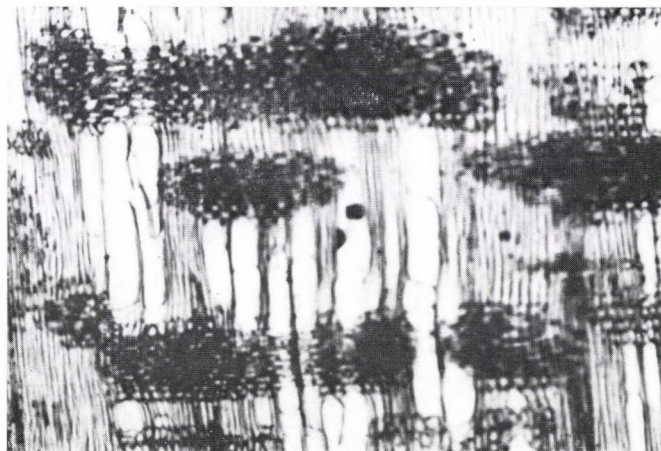


Fig. 3. *A. amorphoides*, corte radial. 100×

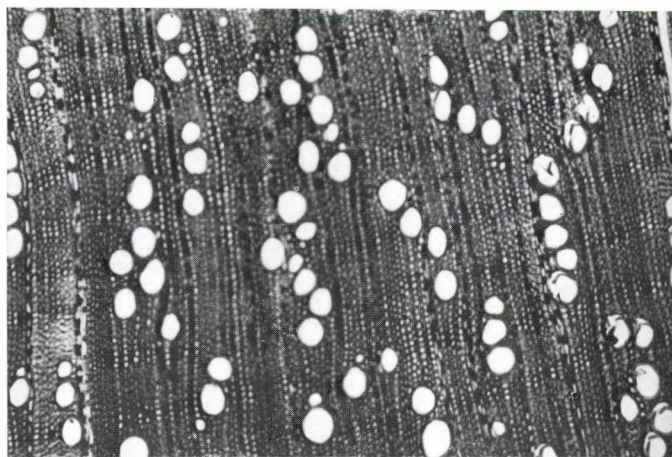


Fig. 4. *A. arborescens*, corte transversal. 100×

de ancho y 2–30 células de altura. Los uniseriados formados por células erectas, con ancho de 5–9–12 μm , mientras que los multiseriados están formados por células procumbentes en la región central y filas marginales de 1–2 células erectas. Ancho de los multiseriados 12–29–40 μm . Los uniseriados con 2–13 células de altura ó 94–197–325 μm ; los multiseriados 8–47 células de altura ó 12–29–40 μm (Figs 2 y 3).

Elementos de la madera;

Elementos de los vasos muy a moderadamente pequeños. Diámetro tangencial 30–54–72 μm , diámetro radial 32–63–85 μm . Grosor de la pared 2–3 μm , con punteaduras intervasculares diminutas de 2 μm de diámetro, redondas y alternas, poro en forma de fisura. Punteado entre los elementos de los vasos y el parénquima semiareolado y de iguales dimensiones. Platina de perforación simple. Elementos de los vasos moderadamente cortos a tallas medias alcanzando dimensiones de 273–419–577 μm de largo. Diámetro medio de las fibrotraqueidas

6–12–18 μm , muy cortas a cortas; 409–763–1270 μm de largo. Grosor de la pared 3–4 μm . Parénquima axial en sección transversal con diámetro medio de 8–15–20 μm y grosor de la pared de 1–2 μm . Las células procumbentes de los radios medulares con dimensiones de largo (radial) de 22–39–57 μm , ancho (tangencial) de 7–10–15 μm y altura (vertical) de 10–14–17 μm ; las células erectas con valores de largo radial de 12–19–30 μm ; ancho (tangencial) de 7–10–15 μm y altura (vertical) de 20–35–60 μm . Las células de los radios medulares con contenidos oscuros.

Alvaradoa arborescens Griseb.

Especie endémica de la región oriental de Cuba. El ejemplar estudiado fué colectado en la Loma Saca la Lengua, Sierra del Cristal, junto a *Simaruba laevis*, *Ilex hypaneura*, *Manilkara mayarensis*, *Myrica shaferi* y *Pera polylepis*.

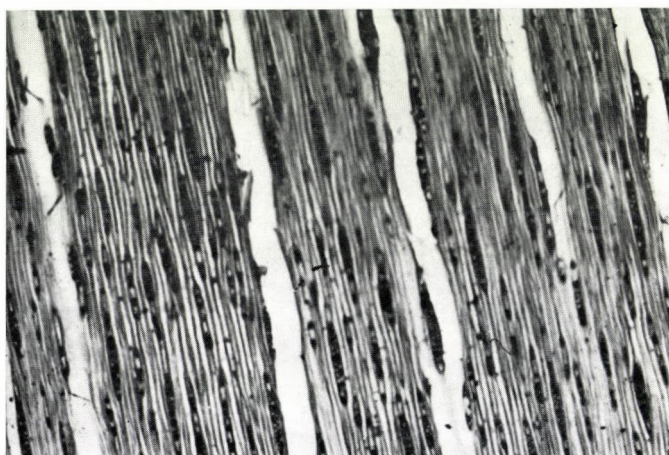


Fig. 5. *A. arborescens*, corte tangencial. 100 \times

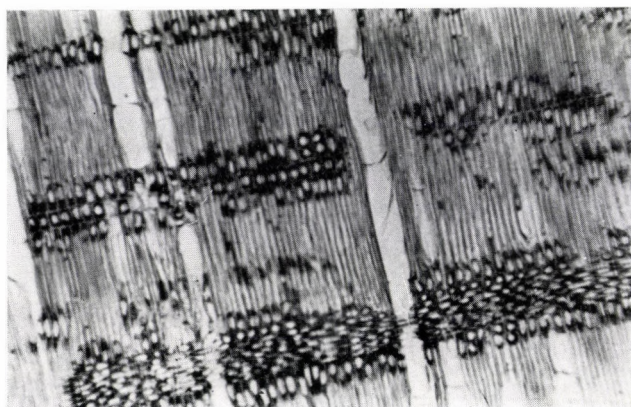


Fig. 6. *A. arborescens*, corte radial. 100 \times

Su madera se caracteriza por la falta de zonas de crecimiento, presenta porosidad difusa, con poros solitarios redondos a ovales y en múltiples radiales u oblicuos de 4 o más elementos (Fig. 4). Traqueidas vasculares presentes. Las fibrotraqueidas son el elemento más abundante del tejido de la madera, distribuidas irregularmente y con formas poligonales en sección transversal. Se observan frecuentemente fibras septadas, las cuales forman bandas. Parénquima axial escaso, las series formadas mayormente por 2 células. Radios medulares heterogéneos de 1-3, mayormente 2 células de ancho (Fig. 5) y 1-18 células de alto. Los uniseriados formados solamente por células erectas, con ancho de 5-12-15 μm , mientras que los multiseriados están formados por células procumbentes que forman el cuerpo central, con ancho de 18-23-28 μm ; y filas ó alas marginales de 1-2 células erectas (Fig. 6), ocasionalmente se observan radios medulares fusionados. Los radios uniseriados con 17 células de altura de 84-196-378 μm ; los multiseriados 7-18 células de altura de 126-248-388 μm .

Elementos de la madera:

Elementos de los vasos muy a moderadamente pequeños, diámetro tangencial 30-56-72 μm ; diámetro radial 30-62-80 μm . Grosor de la pared 3-4 μm , con punteaduras intervasculares redondas, alternas y diminutas de 2 μm de diámetro. Punteaduras de los vasos y parénquima semiareoladas y de iguales dimensiones. Elementos de los vasos muy cortos a elementos de tallas medianas, con largos de 210-471-693 μm . Platinas de perforación simples. Diámetro medio de las fibrotraqueidas 9-14-18 μm , muy cortas a cortas alcanzando valores de 210-1040-1240 μm . Grosor de la pared 3-4 μm . Parénquima axial en sección transversal con diámetro medio de 12-15-18 μm . Las células procumbentes de los radios medulares con dimensiones de largo (radial) de 28-56-80 μm ; ancho (tangencial) de 8-11-15 μm y altura (vertical) de 13-19-33 μm ; las células erectas con valores de largo (radial) de 15-30-38 μm , ancho (tangencial) de 10-13-15 μm y altura (vertical) de 30-49-70 μm . Las células de los radios medulares poseen contenidos oscuros.

Simaruba glauca DC.

El género *Simaruba* se encuentra ampliamente distribuido en América tropical y las Antillas y está representado por unas 6 especies. La especie *Simaruba glauca* se halla distribuida por México, las Antillas, sur de la Florida y parte de Sur-América.

El ejemplar estudiado fué colectado en la reserva natural de El Veral, Guanahacabibes.

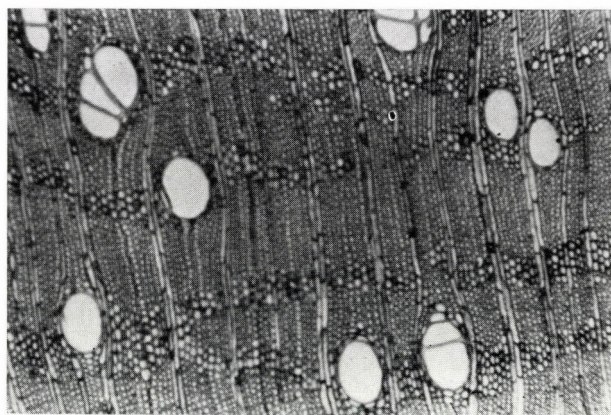


Fig. 7. *S. glauca*, corte transversal. 100 \times

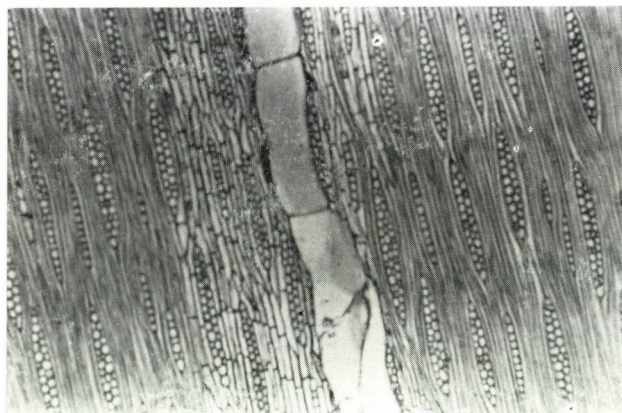


Fig. 8. *S. glauca*, corte tangencial. 100×

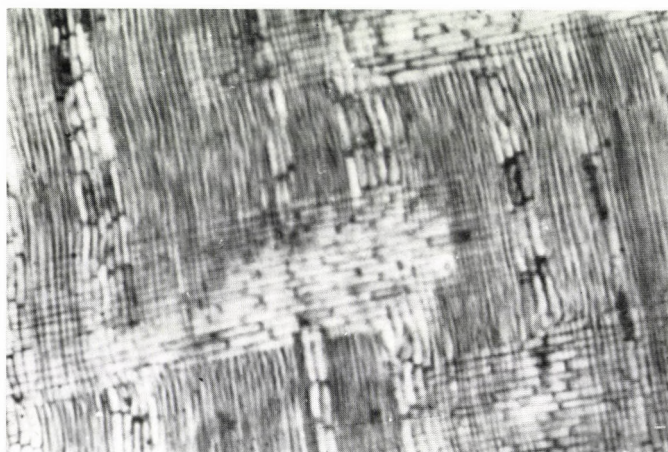


Fig. 9. *S. glauca*, corte radial. 100×

Pinar del Río junto a especies tales como: *Catalpa punctata*, *Hyperbaena racemosa*, *Guaiacum officinale*, *Trichilia glabra*, *Jacaranda coerulea*, *Adelia ricinella* y *Guettarda brevinodis*.

La madera de esta especie, de poca utilidad desde el punto de vista forestal, se caracteriza por la ausencia de zonas de crecimiento, porosidad difusa y poros moderadamente escasos, circulares cuando se presentan solitarios, frecuentes en múltiples radiales de hasta 4 elementos, solo ocasionalmente en grupos (Fig. 7). Las fibrotraqueidas constituyen los elementos más abundantes de la madera y están distribuidas irregularmente. Parénquima axial paratraqueal aliforme y confluyente. Las series del parénquima compuestas por 2–7 células, las que alcanzan dimensiones de 294–412–662 μm de largo y están dispuestas en forma estratificada (Fig. 8). Se observan frecuentemente células cristalíferas septadas con cristales poliédricos. Radios medulares homogéneos, con 1–3, mayormente 1–2 células de ancho y 3–19 células de alto. Estos radios están formados por células procumbentes (Fig. 9), solo muy raras veces fueron observadas células cuadradas aisladas. Los uniseriados con dimensiones de 16–19–23 μm de ancho y 95–173–284 μm de altura; mientras que los bi- y triseriados poseen ancho de 23–34–51 μm y altura de 245–319–435 μm .

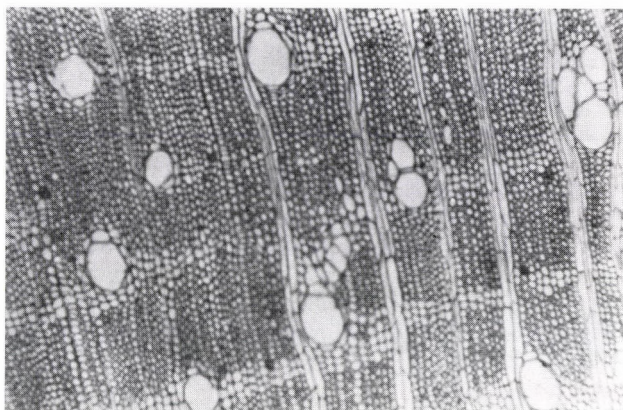


Fig. 10. *S. laevis*, corte transversal. 100×

Elementos de la madera:

Elementos de los vasos moderadamente pequeños a tallas medianas, diámetro tangencial 71–108–150 μm , diámetro radial 87–138–190 μm . Grosor de la pared de 4–5 μm , con punteaduras intervasculares de dimensiones medias, alternas y redondas con 6–8 μm de diámetro y poro en forma de fisura de 2×3 μm . Punteaduras de los radios y los vasos, así como vasos–parénquima axial, semiareoladas y de iguales dimensiones a las intervasculares. Largo de los elementos de los vasos moderadamente cortos hasta dimensiones medias, midiendo 336–410–830 μm . Platinas de perforación simples inclinadas y horizontales. Diámetro medio de las fibrotraqueidas 10–15–20 μm , muy cortas a cortas alcanzando valores del largo de 585–892–1264 μm . Grosor de la pared 2–3 μm . Parénquima axial con diámetro medio de 16–21–27 μm en sección transversal. Las células que forman las series del parénquima tienen dimensiones de 86–111–152 μm de altura. Los radios uni- y multiseriados formados casi exclusivamente por células procumbentes con dimensiones de ancho (tangencial) de 11–18–23 μm ; altura de 19–24–39 μm (vertical) y largo (radial) de 58–110–156 μm .

Simaruba laevis Griseb.

Especie endémica que posee una relativamente amplia distribución en todo el archipiélago cubano. El ejemplar investigado fué colectado en la Loma Saca la Lengaa, Sierra del Cristal, junto a *Alvaradoa arborescens* e *Ilex hypaneura* entre otras.

La madera de esta especie no muestra zonas o anillos de crecimiento, posee porosidad difusa con poros moderadamente escasos, circulares a ovales cuando se presentan solitarios, frecuentes en múltiples radiales de hasta 4 elementos y solo ocasionalmente en grupos (Fig. 10). Las fibrotraqueidas se observan irregularmente distribuidas en la masa del tejido. El parénquima axial paratraqueal aliforme y confluyente y dispuesto en forma estratificada. Las series del parénquima formadas por 2–6 células, las cuales alcanzan largos de 86–107–156 μm . Frecuentemente se observan células cristalíferas septadas con cristales poliédricos. Radios medulares homogéneos de 1–3 células de ancho, ocasionalmente 4 (Fig. 11) y 2–24 células de altura, formados por células procumbentes (Fig. 12) y solo raramente células cuadradas aisladas. Los radios medulares uniseriados con 12–17–23 μm de ancho y 71–156–269 μm de altura; los multiseriados con 19–47–70 μm de ancho y 174–361–498 μm de altura.

Elementos de la madera:

Elementos de los vasos moderadamente pequeños hasta tallas medias, diámetro tangencial $70\text{--}98\text{--}129\text{ }\mu\text{m}$, diámetro radial $90\text{--}127\text{--}172\text{ }\mu\text{m}$. Grosor de la pared $4\text{ }\mu\text{m}$, con punteaduras de dimensiones medias alternas y redondas de $8\text{ }\mu\text{m}$ de diámetro con poros en forma de fisura de $2\times 4\text{ }\mu\text{m}$ incluidos, ocasionalmente extendidos y otros fusionados al de otra punteadura. Punteaduras vasos-radios medulares y vasos-parénquima axial semiareoladas y de iguales dimensiones a las intervasculares. Largo de los elementos de los vasos muy cortos hasta tallas medianas, alcanzando $200\text{--}405\text{--}560\text{ }\mu\text{m}$ de largo total. Platinas de perforación simples inclinadas y horizontales. Diámetro medio de las fibrotraqueidas $14\text{--}17\text{--}21\text{ }\mu\text{m}$ en sección transversal, muy cortas hasta largas, de $616\text{--}1164\text{--}1800\text{ }\mu\text{m}$ de largo, grosor de la pared $3\text{--}4\text{ }\mu\text{m}$. Diámetro medio del parénquima axial en sección transversal $14\text{--}20\text{--}27\text{ }\mu\text{m}$. Altura de las células que forman las series del parénquima $86\text{--}107\text{--}156\text{ }\mu\text{m}$. Los radios medula-

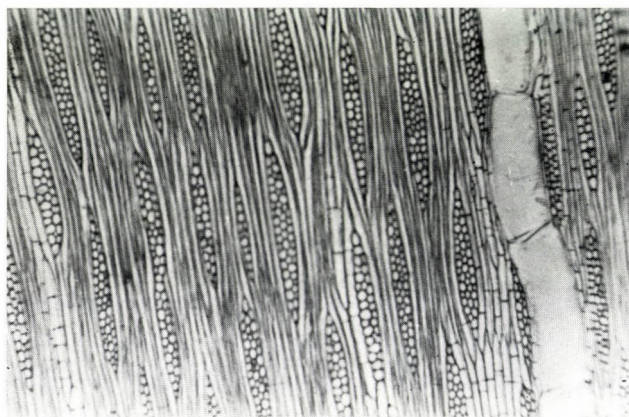


Fig. 11. *S. laevis*, corte tangencial. $100\times$

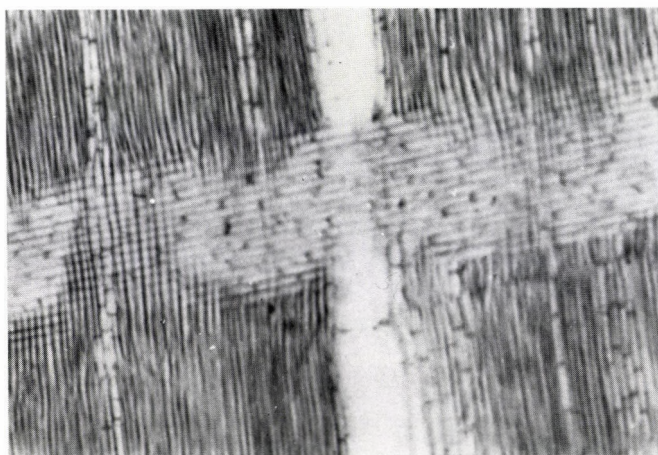


Fig. 12. *S. laevis*, corte radial. $100\times$

Tabla 1

Valores de los principales caracteres observados
(valores expresados en μm)

Especies	Elementos de los vasos				Fibras			
	Largo	Diametro tang.	Diametro rad.	% del total	Largo	Diametro medio	Grosor de la pared	% del total
<i>Simaruba glauca</i>	410	108	138	4	1406	14	3.0	54
<i>Simaruba laevis</i>	405	98	127	6	892	18	3.0	56
<i>Alvaradoa amorphoides</i>	419	55	63	21	763	15	3.0	39
<i>Alvaradoa arborescens</i>	471	56	62	15	1040	14	4.0	47

Especies	Parénquima axial				Radios medulares			
	Largo de las series	Diametro medio	% del total	Homogéneos	Heterogéneos	Ancho en $\frac{1}{4}$ de células	Ancho en μm	% del total
<i>Simaruba glauca</i>	412	21	23	+		1-3	34	19
<i>Simaruba laevis</i>	433	22	17	+		1-4	47	21
<i>Alvaradoa amorphoides</i>	94	16	22		+	1-6	29	17
<i>Alvaradoa arborescens</i>	135	16	24		+	1-3	23	14

res están formados por células procumbentes de dimensiones de ancho (tangencial) de 12-16-23 μm ; altura (vertical) de 12-21-27 μm y largo (radial) de 70-138-211 μm .

La Tabla 1 muestra las dimensiones de los principales caracteres registrados para las cuatro (4) especies investigadas.

Discusión

Muchos autores han señalado la importancia del xilema secundario en la determinación de las relaciones filogenéticas. De esta forma a través de la anatomía de la madera pueden establecerse aquellos caracteres de una especie que son primitivos ó evolucionados solo con respecto a otras especies, siendo en consecuencia el término evolucionado (o especializado) relativo, ya que sugiere que una determinada especie se encuentra a un nivel filogenético superior a otra mas primitiva.

Las especies del género *Alvaradoa* que crecen en Cuba, presentan fibras muy cortas a cortas; elementos de los vasos muy cortos hasta dimensiones

medianas y con punteaduras intervasculares alternas y diminutas. La relación largo de las fibras: largo de los elementos de los vasos, como se observa en la Tabla 1 es de 1,8 para *A. amorphoides* y de 2,2 para *A. arborescens*. Ambas especies presentan además radios medulares heterogéneos y parénquima axial escaso.

Por su parte, las especies investigadas del género *Simaruba* presentan fibras muy cortas a cortas, las cuales llegan hasta la categoría de largas solamente en *S. laevis*; elementos de los vasos moderadamente cortos a medianas tallas con punteaduras intervasculares alternas y medianas dimensiones. La relación largo de las fibras: largo de los elementos de los vasos alcanza para *S. glauca* un valor de 3,4, mientras que para *S. laevis* de 2,2. Los radios medulares son homogéneos y el parénquima axial paratraqueal aliforme y confluyente y dispuesto en forma estratificada. Estos caracteres señalan al género *Simaruba* como filogenéticamente mas evolucionado que *Alvaradoa* desde el punto de vista de la anatomía comparada del xilema secundario.

WEBER (1936) señaló que cada uno de los tipos de la estructura de la madera que caracterizan las diferentes subfamilias constituyen grupos naturales. Nuestros resultados coinciden con esos señalamientos, ya que existen caracteres en la anatomía de la madera de Alvaradoideae que la distinguen de Simaruboidae; sin embargo dentro de los géneros o grupos existe una gran homogeneidad en las características de las maderas, encontrándose como única diferencia notable el número de células de ancho de los radios medulares multiseriados.

REFERENCIAS

- Chattaway, M. M. (1932): Proposed standards for numerical values used in describing woods. *Tropical Woods* **29**: 20-28.
- Engler, A. (1931): Simarubaceae. In Engler, A. und Prantl, K.: *Die natürlichen Pflanzenfamilien*. Auflage I. Teil III Abt. **4**: 202-230.
- Franklyn, G. L. (1946): Preparation of thin section of synthetic resins and wood resin composites, and a new macerating method for wood. *Nature* (London) **155**: 51.
- Hallier, H. (1908): On the origin of the angiosperms. *Bot. Gaz.* **45**: 196-198.
- Loesner, T., Solereder, H. (1905): Ueber die bisher wenig bekannte südamerikanische Gattung *Regiostachys*. *Botanischer Verein der Provinz Brandenburg. Verh.* **47**: 35-62.
- Weber, I. (1936): Systematic anatomy of the woods of the Simarubaceae. *Amer. J. Bot.* **23**: 557-587.

DEVELOPMENTAL ANATOMY OF THE *ARMENIACA VULGARIS* LAM. (ROSACEAE)

J. SZUJKÓ-LACZA

BOTANICAL DEPARTMENT OF THE HUNGARIAN NATURAL HISTORY MUSEUM,
BUDAPEST, HUNGARY

(Received: December 20, 1982)

The inner structure of *Armeniaca vulgaris* was observed from the bud to the ripened fruit. Microsporogenesis occurs in the bud and macrosporogenesis mainly in the opened flower. Stigma-pollen grain interaction continues after double fertilization. Endosperm is first nucellar, then it is transformed to a cellular form in the embryo sac. The union of the free endosperm nuclei and nucleoli result in polyploidy in the secondary endosperm cells. Integuments, the large nucellus and endosperm tissue are transformed to a nutrition source for the embryo, directly and indirectly before its full development. Reserve food for germination is located in the embryo of the apricot.

Introduction

The fruit and the nectariferous area in the flower of the apricot are the most important parts from an economic aspect. Development of the reproductive organs in the bud to the ripened fruit, including the stone fruit is of interest from the biological point of view.

Some anatomical studies on the reproductive organs were published at the beginning of this century (PÉCHOUTRE 1902, HILLMAN 1910, RUEHLE 1924). More recently however, the authors usually focus on only one or two questions or organs of different species. For example, VAUGHAN (1970) was concerned with the structure of oil-seeds including apricot; STERLING (1964) studied the carpels of *Prunus* species, KANIEWSKI (1963) the endocarp of stone fruits; and BERNSEN (1966) concentrated only on the seed-coat of some *Prunus* species.

The micro- and macrosporogenesis in different convarieties of *Armeniaca vulgaris* were studied by MINASJAN (1952, cf. RADIONENKO 1963b), NYUJTÓ and BANAINÉ (1957), MALAKOVA (1963, cf. RADIONENKO 1963a, b), ILIEV (1963), BEREZENKO (1966), BACIU (1970, 1971, 1972, 1977), SAMUSHIA (1971) and SPULJOVIJ (1973). According to these authors, the differentiation of reproductive organs begins in January–February after a short “dormancy”.

According to NYUJTÓ and TOMCSÁNYI (1959), BEREZENKO (1966), BESPECHAL'NAYA (1967), SHOLOKHOV (1970, 1972), MOLNÁR and STOLLÁR (1971), BRÓZIK and NYÉKI (1975), NYÉKI et al. (1974a, b) and NYUJTÓ and BANAINÉ (1974) the development of reproductive organs in the bud depends on climatic effects.

The freeze injury in these early developing organs was studied by SIMONS (1969).

Floral nectaries of the apricot may be of economical importance in bee-farming with respect to the size of fruit gardens. Flowering nectaries were described by PÉTER (1975), the morphological composition of the nectariferous area of *Armeniaca vulgaris* by SZUJKÓ-LACZA

Abbreviations to the figures

a = anther; *ap* = aperture; *bsc* = bud scale leaf; *c* = calyx leaf parenchyme; *cc* = central cells; *ci* = crystal idioblast; *cm* = crushed middle layer; *cnu* = crushed nucellus; *co* = corolla; *cot* = cotyledon; *cy* = cytoplasm; *d* = druse crystals; *dm* = double membrane of the nucleus wall; *emb* = embryo; *en* = endothecium; *end* = endocarp cells; *epi* = epidermis; *epic* = epicotyl; *es* = endosperm tissue; *ez* = embryo; *sac*; *fi* = filament; *fpol* = fused polar nuclei; *fvb* = funicle vascular bundle; *gc* = guard cell; *gec* = generative cell; *h* = hair-cell; *hy* = hypanthium; *hyp* = hypocotyl; *i* = integument; *ii* = inner integument; *m* = marginal cell row of nucellus; *ma* = macrosporocytia; *mi* = middle layer; *mic* = micropyle; *mt* = mitose; *n* = nectariferous area; *ns* = nucleus; *nu* = nucellus; *nui* = nucleoli; *o* = ovule; *ob* = obturator; *oi* = outer integument; *ov* = ovary; *pe* = triploid primer endosperm cell; *pec* = pericarp; *pl* = plasma bridge; *plu* = plumula; *po* = pollen grain; *pol* = polar nucleus; *pot* = pollen tube; *prc* = procambrium; *sc* = sclereid; *sch* = starch; *sec* = separate cytoplasm; *sp* = cell wall thickening under style point; *st* = stomate; *sto* = stomium; *syn* = synergid; *syp* = style point; *ta* = tapetum; *te* = tetrad of microspores; *tr* = transfer cell; *v* = vesicle; *va* = vacuole; *vb* = vascular bundle; *vc* = vegetative cell; *zy* = zygote.

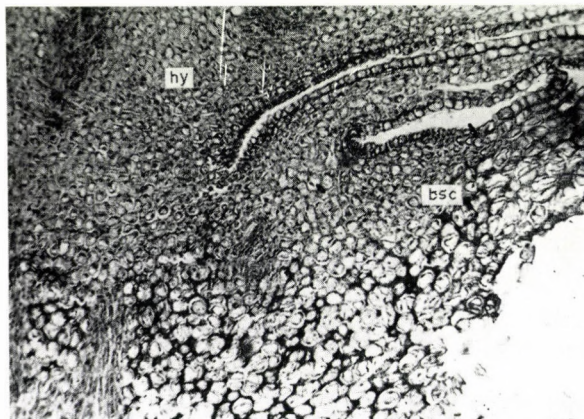


Fig. 1. Longitudinal section from the hypanthium and bud scale leaves. $\times 290$. Photo E. B. SZIKSZAY

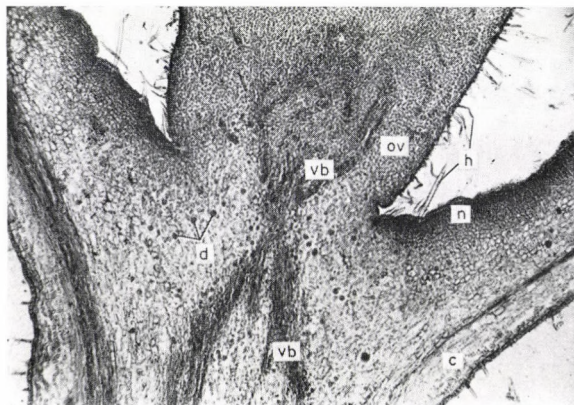


Fig. 2. Venatio in the hypanthium. $\times 115$. Photo E. B. SZIKSZAY

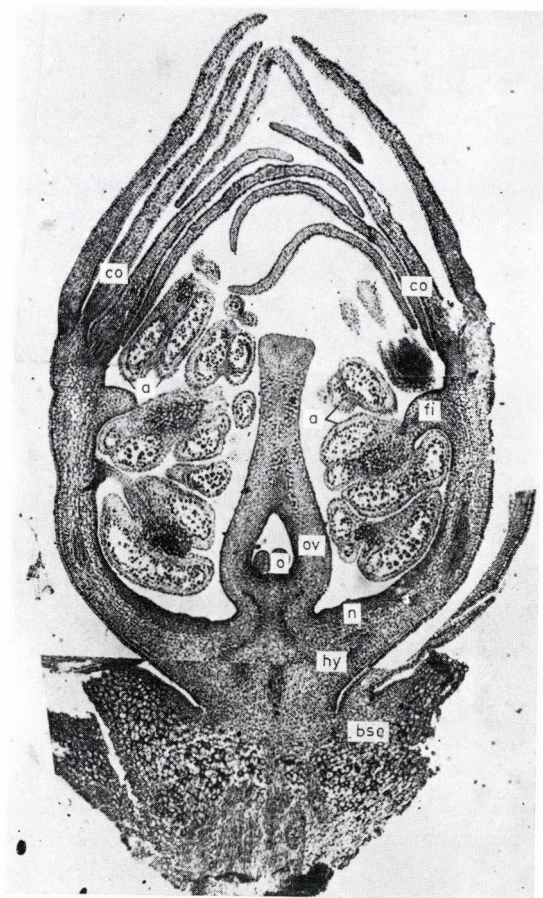


Fig. 3. Longitudinal section of the apricot flowering bud. $\times 115$. Photo E. B. SZIKSZAY



Fig. 4. Cross-section of anther. $\times 730$. Photo E. B. SZIKSZAY

(1982). Nectar producing cells in various species were studied microscopically by VASSILYEV (1969, 1971) and many others (cf. FAHN 1979). After dehiscence of the petals the floral cup remains around the young fruit for a long time. The floral cup abscission process was reported by ROBBINS and RAMALEY (1933) and LOTT and SIMONS (1964, 1968) in different cultivars of apricot.

Integuments, nucellus, embryo, primary and secondary endosperm tissue development were recorded by PÉCHOUTRE (1902), BRANDBURY (1929), BACIU (1977) and RADIONENKO (1963a) while the seed, perisperm, stone-fruit structure were observed by PÉCHOUTRE, PÉNZES (1957), BERNSEN (1966), MORLOVA et al. (1972), MORLOVA et al. (1977). Observations on bud development and microsporogenesis were reported by YELMANOV (cf. SHOLOKHOV 1970),

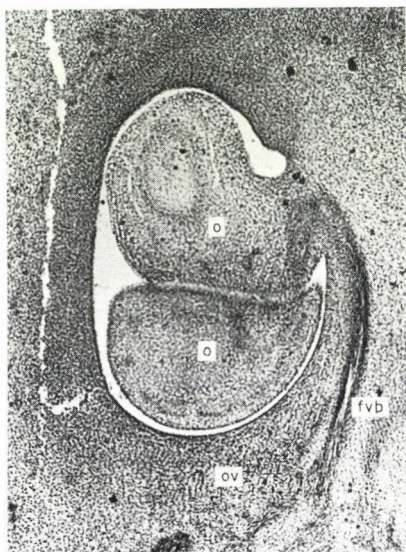


Fig. 5. Two hemitropic ovules in the ovary cavity. $\times 115$. Photo Zs. HATTYÁR-HIDAS

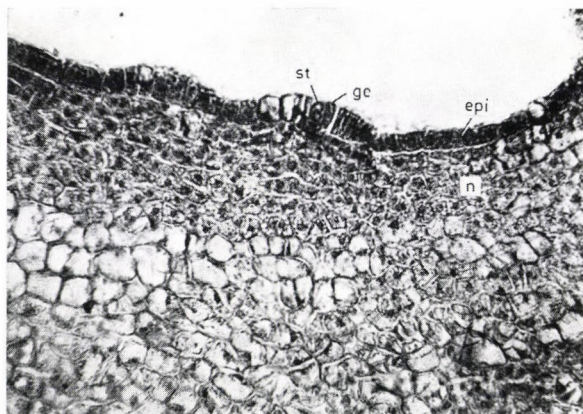


Fig. 6. Stomata and guard cells in the nectariferous area. $\times 730$. Photo E. B. SZIKSZAY



Fig. 7. Tetrads in the callose envelopment. $\times 730$. Photo E. B. SZIKSZAY



Fig. 8. Cross-section of filament and anthers. $\times 290$. Photo E. B. SZIKSZAY

BACIU (1970), SAMUSHIA (1971), SPULJOVIJ (1973), RADIONENKO (1963a, b), YELMANOV (cf. SHOLOKHOV 1970, 1972) distinguished six, while BACIU (1970) two developmental phases in the bud during the blossoming period.

Micro- and macrosporogenesis, fertilization and development of the embryo and endosperm were studied by RADIONENKO (1963a, b). The correlation between the embryo- and endosperm tissue development was summarized by BACIU (1977). However, observations on the development of the whole reproductive organ are lacking in the literature. In this paper the differentiation and development of the reproductive organs of *Armeniaca vulgaris* are described.



Fig. 9. Exo- and endothecium differentiated in the anther wall. $\times 750$. Photo E. B. SZIKSZAY



Fig. 10. Pollen grains in the anther. $\times 750$. Photo E. B. SZIKSZAY

Material and methods

The branches and twigs of *Armeniaca vulgaris* c.v.-235 were collected in an experimental fruit garden in Cegléd and in a private one in Dömsöd from February till July of 1979–80. After removing the bud scale, the bud and all other organs were fixed in Nawasin solution, embedded in paraffin and stained with toluidin-blue. The ovary and later on the fruit were shaved, and the skin epidermis hairs were removed. Then sections of 12–20 μm thickness were prepared from apricots at different developmental phases. The sections are housed in the Botanical Department of the Hungarian Natural History Museum, Budapest.

Development of the buds depends on their topography on the branch and twig. Consequently in several-year-old branches, buds in various developmental phases can be found at the same time (cf. SZUJKÓ-LACZA 1982). The distance between two free endosperm nuclei was measured in 10.55% of the 256 nuclei. The diameter of the nuclei and nucleoli was measured before the separation of the cytoplasm surrounding the nuclei. After the separation of the cytoplasm the size of the "cell" and also the diameter of nucleus and nucleoli in one unit of cytoplasm were measured. Based on these data, the volume (μm^3) of the cytoplasm, nucleus and nucleoli considered as spheric forms were calculated.

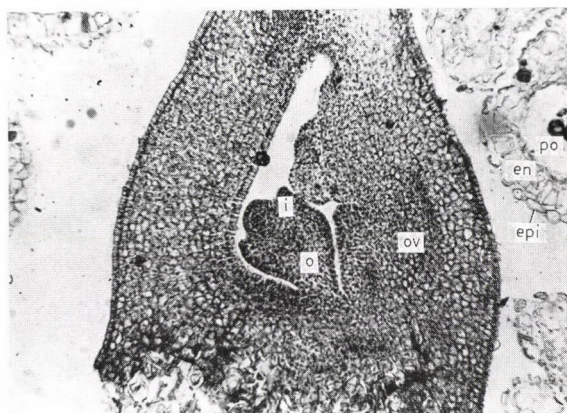


Fig. 11. Longitudinal section of the ovary. $\times 290$. Photo E. B. SZIKSZAY

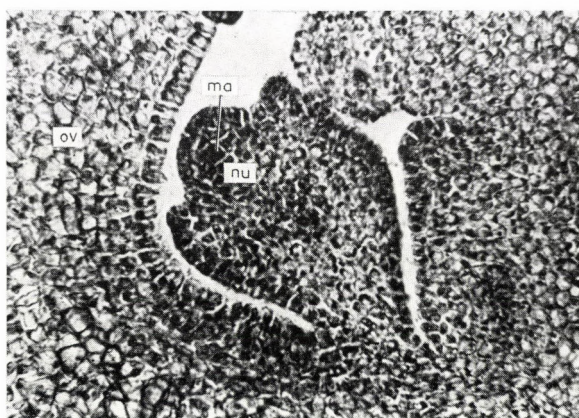


Fig. 12. Megasporocyte in the nucellus epidermal layer. $\times 730$. Photo E. B. SZIKSZAY

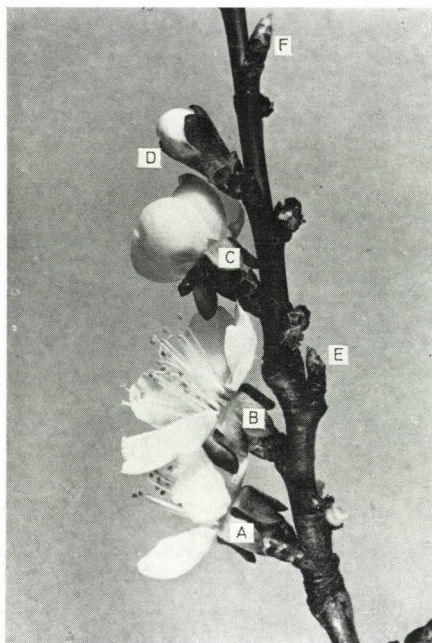


Fig. 13. Blossoming sequence in a two-year-old branch. Photo I. RÁCZ

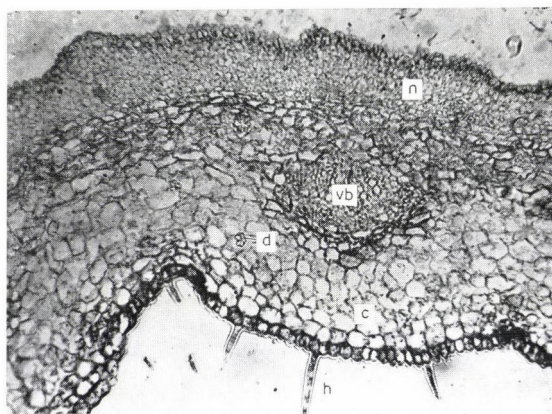


Fig. 14. Cross-section from the inner and outer cup. $\times 290$. Photo Zs. HATTYÁR-HIDAS

Results

In a less developed bud cells of the inner bud scale are rich in cytoplasm, and the nucleus is large in epidermal cells (Fig. 1). Between the cork and pith parenchyma the cylindrical central vascular plexus is visible in the pedicel. In the pith parenchyma there are druse crystal idioblasts.

The central vascular plexus (stele in the future) is arch-like in the hyphant (Fig. 2) and the trace of the calyx lobe, the petals and stamens diverge from the arch apex. Development of the veins in the carpel of numerous *Prunus* species was observed by STERLING (1964). Our results on *Armeniaca vulgaris* confirm his findings.

The thicker traces belong to the calyx and corolla leaves and from these ramify a thinner trace of anthers according to HILLMAN (1910). The trace elements are together in the hyphant and in the inner calyx (Fig. 3) and the anther veins ramify from these, first at the lower level, and the calyx and corolla trace ramification happens above them (Fig. 3).

The outer and the inner calyx are unified here (Fig. 3), but the cells of the nectar producing area are small and rich in cytoplasm, and the stoma differentiation does not begin among the epidermal cells (Fig. 3). This differentiation takes place in the epidermis of the calyx lobe although the stoma cells are in close connection with each other.

The petals are five to six cell rows thick. There is a parenchyma layer around the central vascular bundle in the filament (Fig. 4). These will become fibre parenchyma cells later on. Tannin containing thick-walled cells are found between the two anthers (Fig. 9). There are two or three cell rows in the middle-layer under the epidermis of the anther wall (Fig. 7); the tapetum cells have 1, 2 or 3 nuclei within the dense cytoplasm. The microspore mother cells are in the

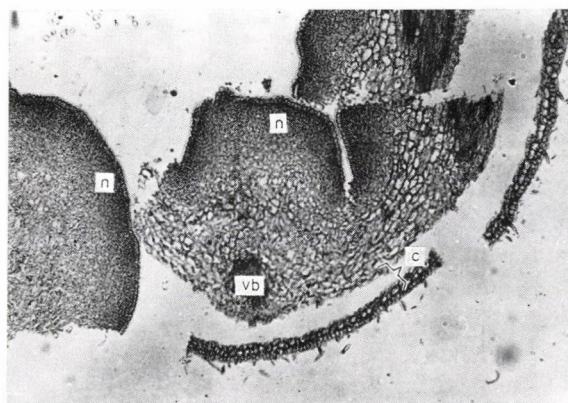


Fig. 15. Wave-like surface of the nectar producing part. $\times 115$. Photo E. B. SZIKSZAY



Fig. 16. Nectar producing tissue with large hair and modified stomata. $\times 730$. Photo E. B. SZIKSZAY

late telophase. The meiosis of the pollen mother cells in *Armeniaca vulgaris* were of particular interest to RADIONENKO (1963b), BACIU (1971), SAMUSHIA (1971), SPULJOVIJ (1973) in Ukraine, Romania and Georgia. According to BACIU (1971) meiosis happened in five hours, SPULJOVIJ found that the pollen mother cells appeared simultaneously and besides the microspore tetrads pollen mother cells were also found (SAMUSHIA 1971). In countries south east of Hungary meiosis takes place in the first decade of February, though the buds are only in the swollen phase. (RADIONENKO l.c.). This process happened in the hardly swollen buds of cv. "Magyar kajszai" in the second decade of February 1980. In the hole of the bottle-shaped ovary (Fig. 3) the hemitropic ovules appear as two protuberances above each other (Fig. 5). The bases of the hair cells are visible among the epidermal cells of the ovary.

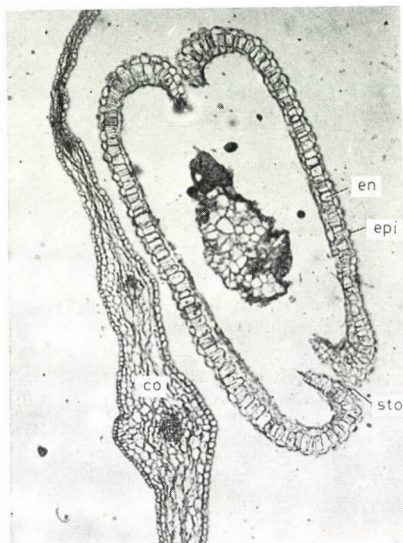


Fig. 17. Petal cross-section and opened anther. $\times 290$. Photo Zs. HATTYÁR-HIDAS

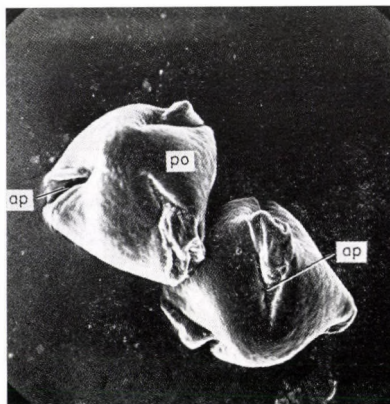


Fig. 18. Young pollen grain. $\times 940$. Photo E. GONDAR

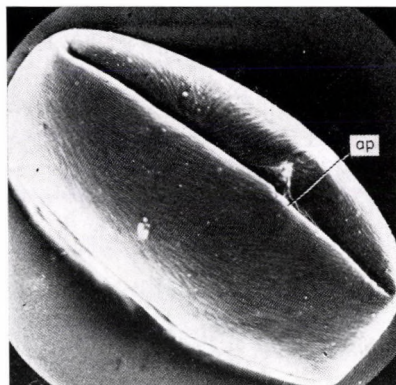


Fig. 19. Ripened pollen grain. $\times 2200$. Photo E. GONDAR



Fig. 20. Two polar cells in the embryo sac. $\times 750$. Photo Zs. HATTYÁR-HIDAS

The stoma cells were differentiated in the inner epidermis of calyx and style epidermis and also in the nectariferous area (Fig. 6) in the slightly swollen buds. Cells are rich in cytoplasm and the procambium occurs in the apex of the corolla leaves after an intensive cell differentiation (Figs 3, 9). The anthers are big and in their loculaments — chambers — there are microspore tetrads in a callose envelope (Fig. 4). Cells of the secreting tapetum layer are rich in cytoplasm; the middle layer comprises two or three cell rows (Fig. 4). Disruption of the middle layer begins after dissolution of the tapetum cells (Fig. 7). The tetrads and microspore mother cells exist side by side, in agreement with SPULJOVIJ's (1973) observations. In the more swollen buds the first hairs develop among the epidermal cells of the calyx and ovary.

The endothecium cells develop in the anther wall (Figs 8, 9, 10), though they have cytoplasm and nucleus. The inner row of the middle layer is almost absent and only the nucleus remains from the tapetum cells (Fig. 9). This sequential dissolution of tapetum and the inner row of the middle layer suggests that the wall of the pollen grain may not be built up solely by tapetum cells.

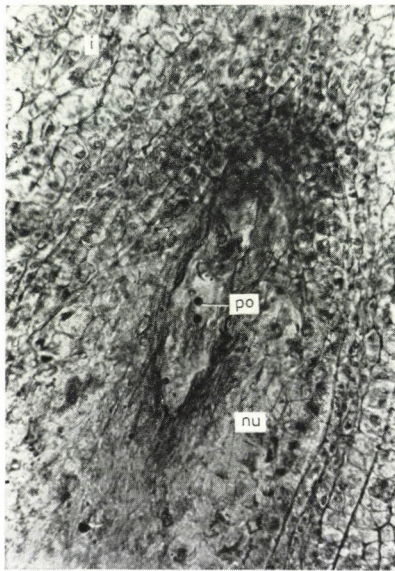


Fig. 21. After the union of the polar nuclei before the fusion of the nucleoli in the embryo sac. $\times 730$. Photo Zs. HATTYÁR-HIDAS

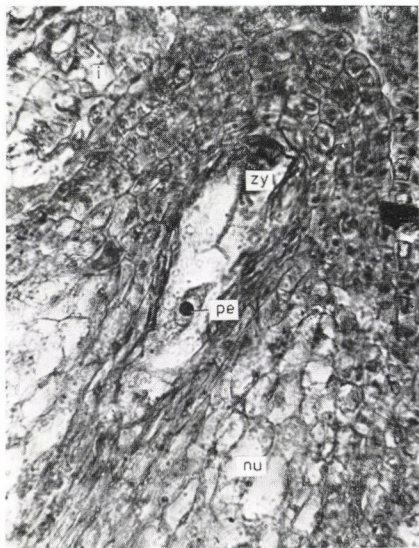


Fig. 22. The zygote, one of the synergids and the primary endosperm cell in the embryo sac. $\times 750$. Photo Zs. HATTYÁR-HIDAS

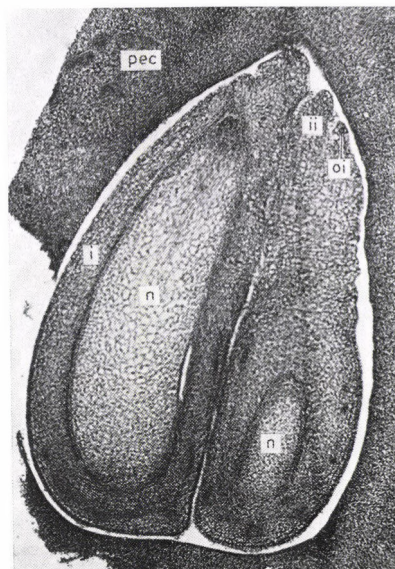


Fig. 23. Two ovules in the ovary after completion of double fertilization. $\times 120$. Photo E. B. SZIKSZAY

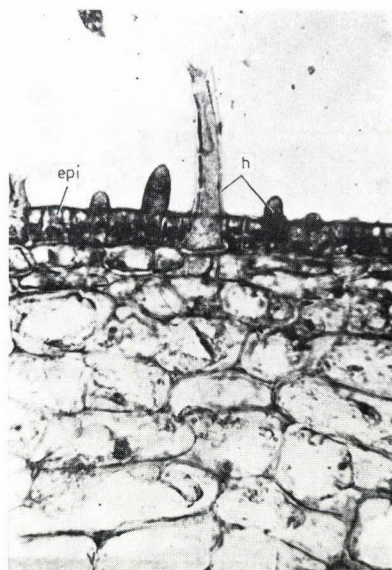


Fig. 24. Hair cells in the exocarp. $\times 730$. Photo Zs. HATTYÁR-HIDAS

Cells of the nectar producing area are rich in cytoplasm and six to seven rows deep. In the pollen grains there are one or two nuclei. Traces of vascular bundle appear in the ovary. Beside the hair cells, the stomata are also differentiated in the epidermis of the ovary.

The integument and nucellus begin to differentiate in the ovule of the ovary hole (Fig. 11). The macrospore mother cells can be found in the subepidermal layer of the crassinucellate nucellus (Fig. 12).

The substomatal chamber evolves under the stoma on the wave-like surface of the nectariferous area. The nectar producing cells are arranged hemispherically, or form rows and columns under the stomata.

Reproductive buds are swollen, but the scale leaves cover each other in them. Vegetative buds are hardly swollen. There are numerous druse crystals in the mesophyll of the scale leaves. Vascular bundles stain strongly in the pedicel and the cell size increases in the petals.

Hair cells are big and substomatal chambers form in the calyx's epidermal layer. The pollen aperture is visible in the pollen grains situated in the chamber. The macrospora mother cell remains in the same state in the ovule.

Scale leaves are opened a little, the apex of the corolla rises in the second half of March. The vegetative buds are elongated and a little swollen (Fig. 13E). Wall thickening of the epidermal and subepidermal cells of the scale leaves seems to be characteristic. There is cell elongation in the apex of corolla leaves. Hair cell division appears among the corolla epidermal cells. The basal part of the adherent sepals appears as a wave-like surface around the ovary (Figs 14, 15). More parenchyma has developed in the hyphant till now.

The inner layer (3–4 cell rows thick) is separated from the outer one by a middle layer two or more cell rows thick, which encompasses the vascular bundles of the anthers, too (Fig. 14), in the base of the ovary. This middle layer is an abscission tissue and the inner or hard calyx will be separated from the outer calyx by this in the future (cf. SZUJKÓ-LACZA 1982). The adherent parenchymatic part of the anthers and some inner cell rows of the hyphant together comprise the nectariferous area (Figs 14, 15).

GULYÁS (1975) divided the nectaries into two groups according to the presence or absence of the vascular elements in them. Considering the absence of the vascular bundle in the apricot, this species belongs to the second group. The metabolic supply of the nectariferous area may be provided from the vascular bundles of the different flower parts.

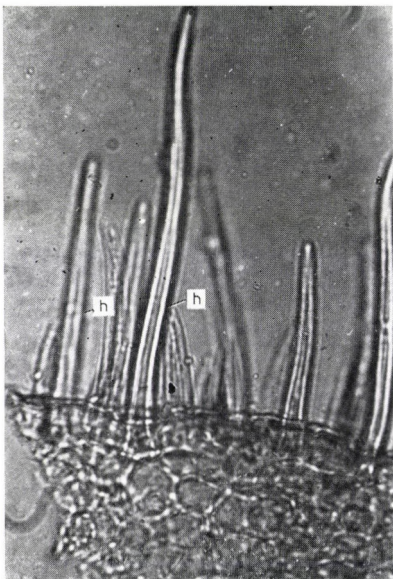


Fig. 25. Hairs in the surface of the pericarp. $\times 730$. Photo Zs. HATTYÁR-HIDAS

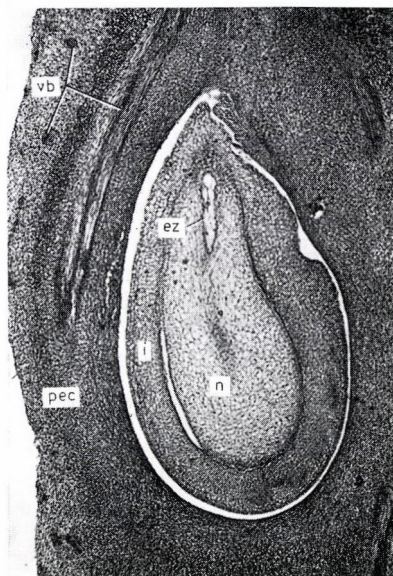


Fig. 26. Longitudinal sections of the ovary after double fertilization. $\times 120$. Photo Zs. HATTYÁR-HIDAS

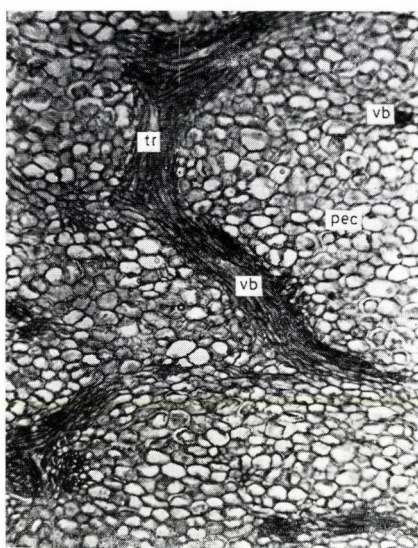


Fig. 27. Venation nets in the pericarp. $\times 290$. Photo Zs. HATTYÁR-HIDAS

Wall thickening of the endothecium cells begins in the anther wall. Pollen grain forms a triangle (Fig. 18). Hair cells are large and rich in cytoplasm, the nucleus is also big in the epidermal cells of the ovary. The stomata are open in it and belongs to the paracytic type. According to PANT's (1965) observations this type is of a mesogenous origin. The ovules have

increased considerably in the ovary hole. Petals cover each other, but the flowers overgrow the bud scales (Fig. 13D). The vegetative buds open subsequently and the shoot apex is visible. Elongation and expansion of calyx and corolla are characteristic; there are big hair cells and stomata among the epidermal cells of the nectariferous tissue (Fig. 16). The base of these hair cells is polygonic and the cells remain at the same level as the epidermal cells.

The anthers are closed, and the cell wall thickening of the anther wall takes place continuously. The four macrospore cells developed in the ovule, in another case there were already two cells in the embryo sac. The style is as high as the outer or upper ring of stamens (Fig. 13B). The petals are opened, the surface of the ovary and style are densely covered with hairs. There are four or eight nuclei in the embryo sac of the ovule. In the latter case the antipodal cells are relatively small, but they have a dense cytoplasm. Druse crystals can be

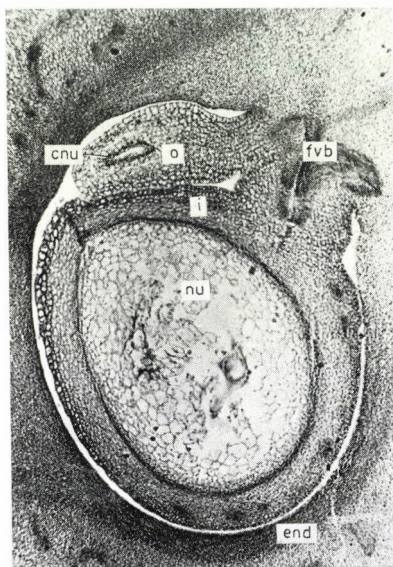


Fig. 28. Fertilized and degenerated ovule in the ovary. $\times 150$. Photo E. B. SZIKSZAY

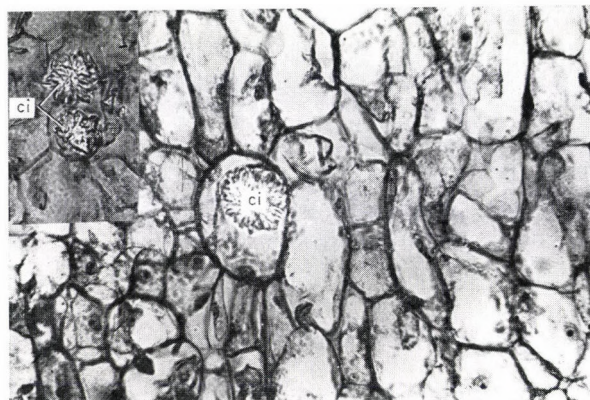


Fig. 29. Caoxalate druse crystals in the pericarp. $\times 730$. Photo Zs. HATTYÁR-HIDAS

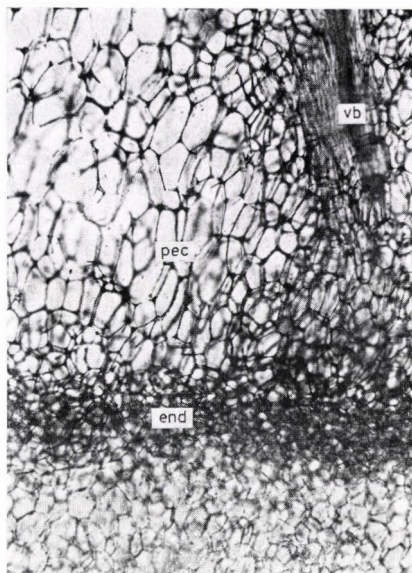


Fig. 30. Size difference between the endo- and pericarp cells. $\times 300$. Photo Zs. HATTYÁRHIDAS

found in the lower part of the hyphant (receptacle) and in the apical part of the integuments. The style overgrows the sepals (Fig. 13A) in the flower situated on the lowest part of the two-year-old branch. The ovary may have a length of 10 mm in some convarieties but usually it is shorter. Anthers of the lower stamens are dehiscent (Fig. 17) while falling out of the dark colour pollen grains (Fig. 19) from there. Calyx, corolla and stamens have differentiated earlier and the calyx teeth has curved completely (Fig. 13A). Germinating pollen grains appear in the stigma surface and begin the union of central cells (Figs 20, 21); the egg-cell has been fertilized earlier in the embryo sac.

Double fertilization takes place after the 2nd or 3rd day and the zygote can be observed only on the 4th day (Fig. 22) after the efflorescence according to RADIONENKO (1963a, b). The antipod cells remain dense in cytoplasm after fertilization. In case of artificial pollination fertilization needs 36–40 h (SAMUSHIA 1971). The two ovules develop inequally in the ovary, consequently the fertilization process may alter in time.

Petals are dropped or drying, anthers of the upper stamens are dark, the stigma is yellow-green and water-colour drops appear on the surface. The curved teeth of the calyx are vivid red, which is a characteristic feature of apricots. Calyx abscission was first studied by ROBBINS and RAMALEY (1933). According to their studies, a basal ring develops before the losing of the calyx. The development of the calyx was divided into stages by LOTT and SIMONS (1968). In stage III a phellogen tissue appears and then a phellem around the ovary. The abscission zone emerges in stage VIII and it results in the losing of the calyx. The remaining calyx round the ovary protects it from frost.

Freezing injuries of different tissues of a young fruit were studied by SIMONS (1969). Damage from freezing is also present in the deeper layers if the fruit was in the developmental stage X and the calyx fell earlier. The mesocarp of the frozen fruit separates at the distal end of the pedicel.

Vascular bundles are the most sensitive, they often burst. Discontinuity in the mesophyll (pericarp) tissue is also characteristic after charge and water-containing hollows appear in it. Deformation of the tissues occurs in the apex of the ovule and integument separately. Endosperm cells are crushed and grouped in a mass in the chalazal end of the embryo sac. The endocarp opens along a raphe.

Returning to our observation in the next developmental stage we found that the calyx and corolla finished their development, and the teeth of calyx curved completely (Fig. 13B). Numerous pollen grains germinate on the stigma; double fertilization occurred in one of the embryo sacs (Fig. 23), rarely in both of them in the ovary. The zygote and the primary endosperm cells are in a "resting period", antipodal cells disappear. Elongation of the embryo sac along a longitudinal axis is significant. Expansion and change in the form of the embryo sac of *Prunus cerasus* were studied by CZOSNOWSKI (1966) in detail. There are some similarities between the embryo sacs of *Armeniaca vulgaris* and *Prunus cerasus*. *Armeniaca* has a typical sand-glass-like embryo sac and in the *Prunus* it has a tube- or sac form. The obturator cells are large, rich in cytoplasm, they can be supposed to be in an active secreting phase during the resting period of the zygote and primary endosperm cells.

Obturator cells originate from the integuments here (Fig. 23), contrary to the *Pimpinella anisum* (cf. SZUJKÓ-LACZA 1975). Obturator cells are characteristic of the Pomoideae (cf. RUEHLE 1924).

The corolla leaves fall; the stigma surface is brown, and in some other flowers only the stamens and the calyx remain. The cells are arranged in rows and columns in the nectariferous area, but its surface is wave-like in this flower. The nectar producing cells are small in the first three rows and increase in size under these. The one-cell hair cell differentiation takes place among the epidermal cells of the ovary continuously (cf. RUEHLE 1924). The basal part of the hair cells intrude into the subepidermal layer (Fig. 24), which has developed earlier. Hair cell development of *Prunus persica* belonging to the Pomoideae subfamily was also

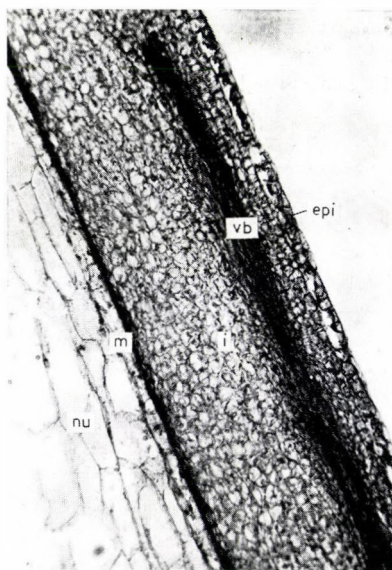


Fig. 31. Longitudinal section from the integuments and nucellus of the ovule. $\times 290$. Photo Zs. HATTYÁR-HIDAS

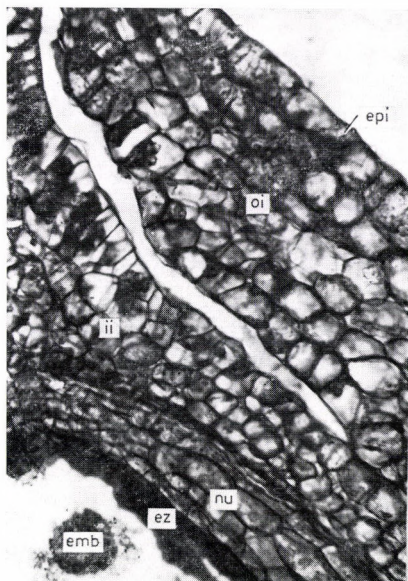


Fig. 32. The union of the two integuments near to the apex. $\times 800$. Photo E. B. SZIKSZAY



Fig. 33. Pollen tube in the micropyle. $\times 1400$. Photo Zs. HATTYÁR-HIDAS

observed by DORSEY and POTTER (1932). They distinguished a buffer and a shorter type. Their development was compared to the initial, the transitional and to the ripened phase of the fruit. The first hair differentiations begin in the ovary wall in the bud of the *Armeniaca vulgaris*, and these first hairs remain also on the ripened fruit. The first hair cells emerge by the periclinal divisions of the epidermal cells. After an elongation their basal part extends



Fig. 34. The zygote and the primary endosperm cell in the embryo sac. $\times 730$.
Photo Zs. HATTYÁR-HIDAS

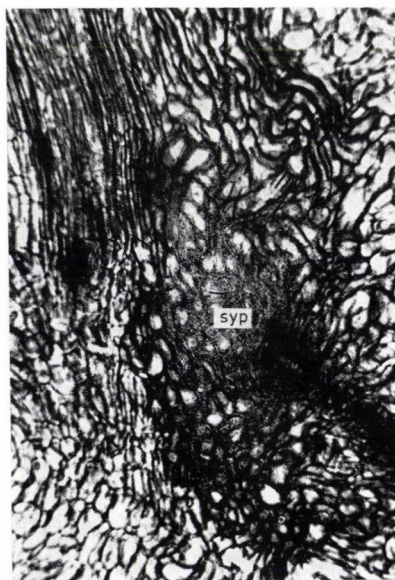


Fig. 35. Secondary thickened cells at the style-point. $\times 290$. Photo Zs. HATTYÁR-HIDAS

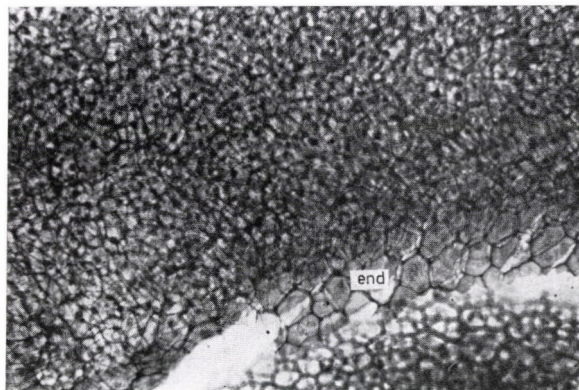


Fig. 36. Endocarp cells in a herring-bone pattern. $\times 730$. Photo Zs. HATTYÁR-HIDAS

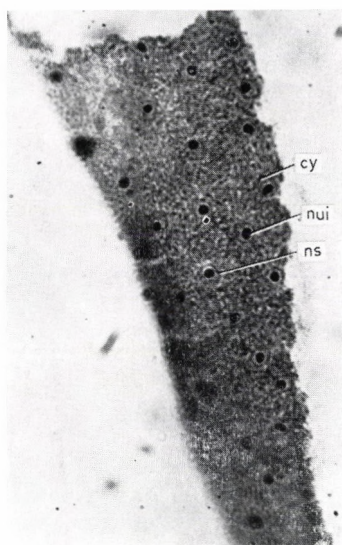


Fig. 37. Free endosperm nuclei. $\times 750$. Photo E. B. SZIKSZAY

into the subepidermal layer. These first hair cells are long and rich in cytoplasm. The nucleus is in the centre of the cell, and wall thickening takes place (Fig. 25). Cell-wall thickening begins at the base of the hair cells and some appendages develop. The hair cells are introduced into the intercellular spaces by them. These first hair cells often have a length of $1000\ \mu\text{m}$. A second "generation" of the hair cells develop after withering and falling of the corolla leaves. They are $200\text{--}300\ \mu\text{m}$ long in their developed phase. The third "generation" of hair cells grow around the first ones and appear almost simultaneously with the beginning of embryo differentiation (Fig. 24). They are blunt and only $100\ \mu\text{m}$ long. Cell wall thickening happens in every hair cell irrespective of their size.

The peri- and endocarp of the ovary is parenchymatic (Figs 23, 26, 27, 28, 29, 30). Vascular bundles constitute a network system (Fig. 27). One vascular bundle grows to the

endocarp and it originates from the pedicel and ends in the chalazal part of the ovary (Fig. 28). According to RUEHLE (1924) this vascular bundle starts at the lower part of the placenta. The vascular bundle having a procambial origin ends in a parenchymatic cell group at the chalaza (cf. RUEHLE). There is a mass of cells through the nucellus which have no own vascular bundle, so the nutrients can reach them through the integuments (Figs 26, 28).

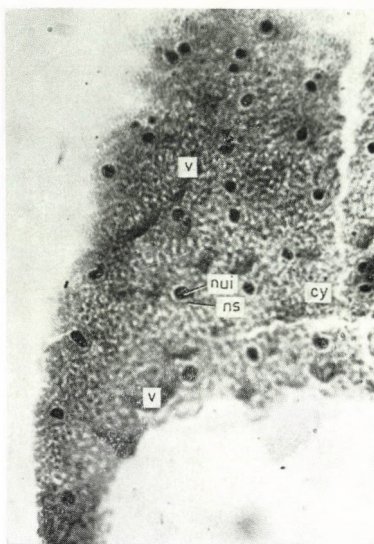


Fig. 38. Free endosperm nuclei in the micropylar end of the embryo sac. $\times 750$. Photo E. B SZIKSZAY

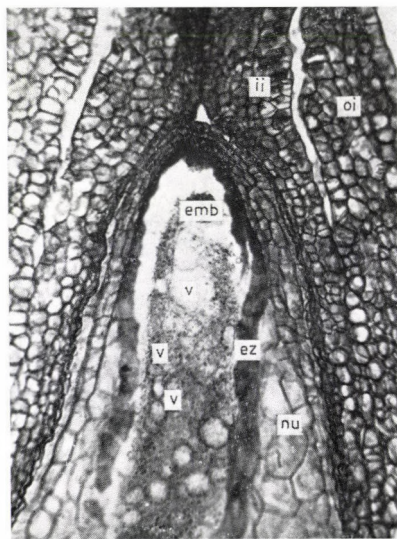


Fig. 39. Spherical embryo and the endospermal vesiculation in the embryo sac. $\times 300$. Photo Zs. HATTYÁR-HIDAS

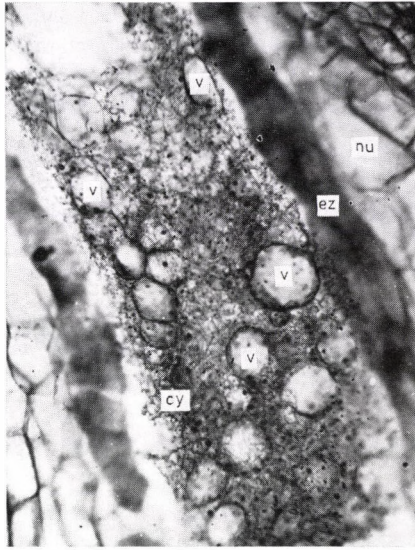


Fig. 40. Free endosperm nuclei and endospermal vesicles. $\times 730$. Photo Zs. HATYÁR-HIDAS

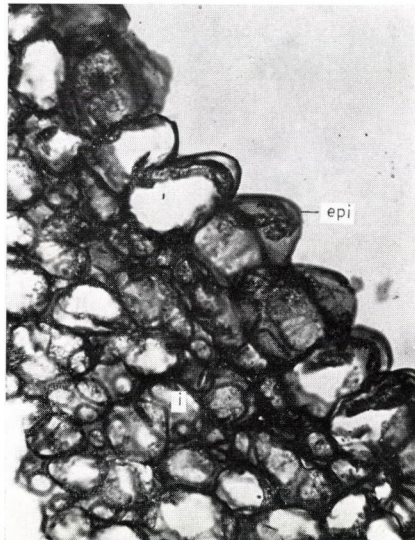


Fig. 41. Secondary thickening in the cells of outer integument $\times 730$. Photo Zs. HATYÁR-HIDAS

Robust druse-crystal idioblasts and often twins (Fig. 29) are found in the mesocarp of the fruit. Similar crystal idioblasts occur in the cork parenchyma of the style and also in the micropylar end of the integuments.

Fruits are 5–6 mm long and 3–4 mm wide, they are as long as the cup tube. The teeth of the cup are red and the outer calyx (cf. SZUJKÓ-LACZA 1982) is still alive. Stamens are dried, the style is yellow-green and there are numerous pollen tubes in it.

New hair cells are differentiated in the exocarp. Additional procambial bundles appear in the mesocarp (later on pericarp) beside the previously existing ones. Three or four druse-crystal idioblasts often form groups in it. Cells of the endocarp are small (Figs 28, 29, 30). Dorsal epidermal cells of the outer integument show characteristic cell-wall thickening (Fig. 31). External integument is a network of vascular bundles, most of them proceed from the chalazal end towards the micropylar region. Evolvement of these vascular bundles happened by further differentiation of the funicular vein.

The outer and inner integuments are separated from the micropylar end to the upper one at the 1/4 length of the ovule (Fig. 32). There are pollen tubes in the micropyle (Fig. 33).

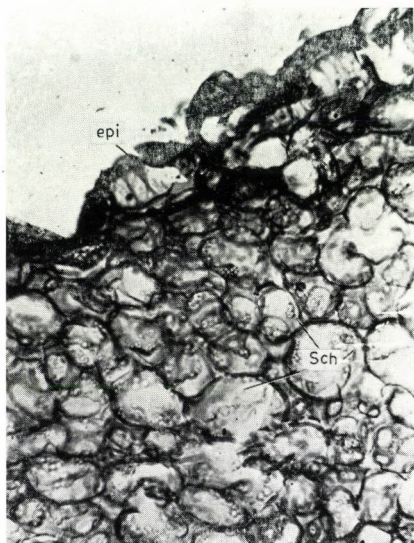


Fig. 42. Starch grains in the integument cells. $\times 730$. Photo Zs. HATTYÁR-HIDAS

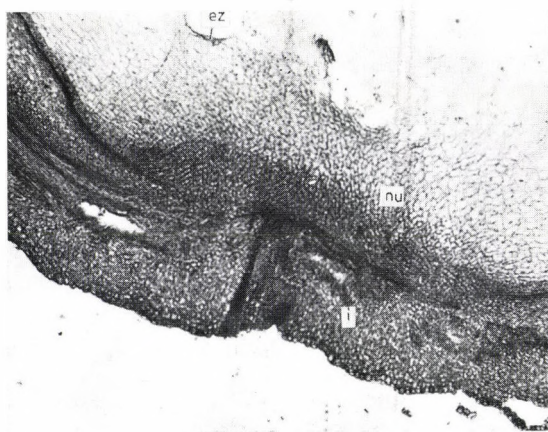


Fig. 43. Cell differentiation and lysis in the nucellus at the chalaza. $\times 115$. Photo Zs. HATTYÁR-HIDAS

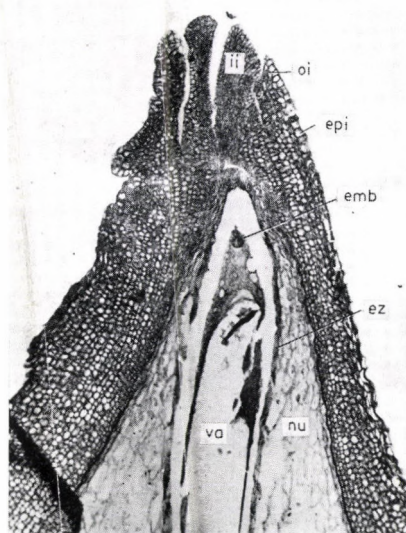


Fig. 44. Embryo, free endosperm nuclei, vesicles and a central vacuole in the embryo sac. $\times 150$. Photo Zs. HATTYÁR-HIDAS

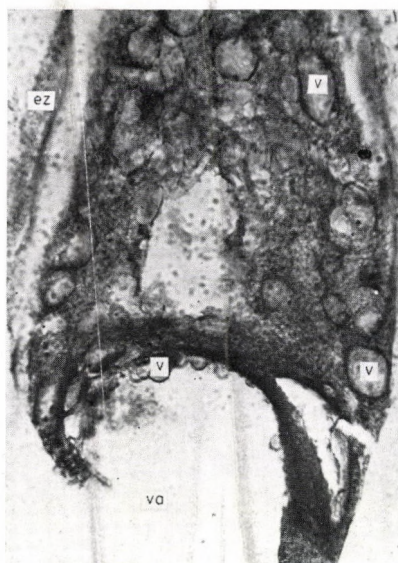


Fig. 45. Vesicles and the central vacuole in the embryo sac. $\times 730$. Photo Zs. HATTYÁR-HIDAS

The nucellus has a meaningful mass (Figs 26, 28). The zygote is beneath the micropyle and the triploid primary endosperm is located in the centre of the embryo sac (Fig. 34). The second ovule cannot develop in the ovary hole, the inner integument and the nucellus are crushed in it (Fig. 28). We can suppose that the fertilization has not taken place in this case.

The fruits are 8–9 mm long but they are 1–2 mm thicker than others situated above at the same time. Vascular bundles are surrounded by more transfer cell rows (cf. PATE and

GUNNING 1972), which are rich in cytoplasm. Sometimes they have more than one nucleus in one cell, their size and form are variable (Fig. 27) and touching the neighbouring cells by a narrow projection.

In the 13 mm long fruit the style and the stigma first dry then fall. The third "generation" of hair cells is differentiated in the exocarp. Cell wall thickening begins in the outer cell rows of the pericarp. The trachea thickens only helically or spirally, the phloem and transfer cells are short in the vascular bundle network of the pericarp. Cells of the endocarp remain small and there is vascularization in this tissue. Some new features appear in the ovule

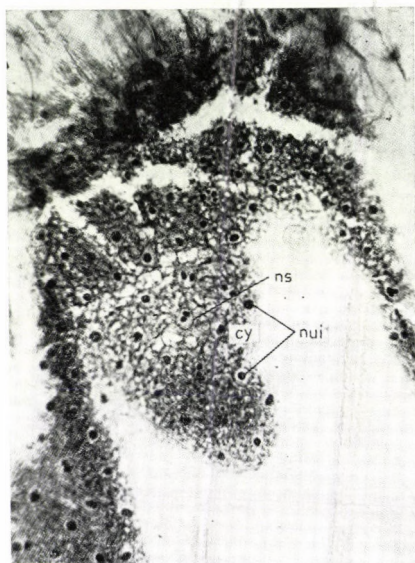


Fig. 46. Free endosperm nuclei after vesiculation process. $\times 300$. Photo E. B. SZIKSZAY

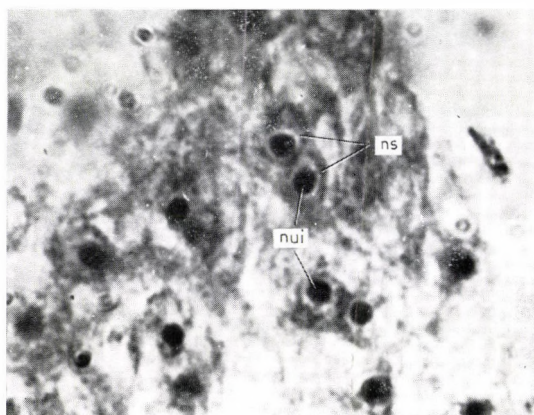


Fig. 47. The fusion of the free endosperm nuclei in variable form. $\times 1200$. Photo Zs. HATTYÁR-HIDAS

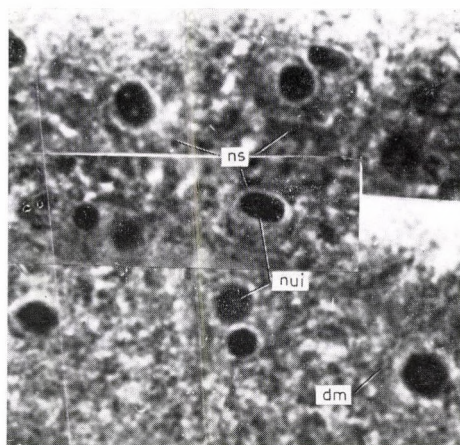


Fig. 48. Fusion process of the free endosperm nuclei and nucleoles. $\times 1400$. Photo Zs. HATTYÁR HIDAS

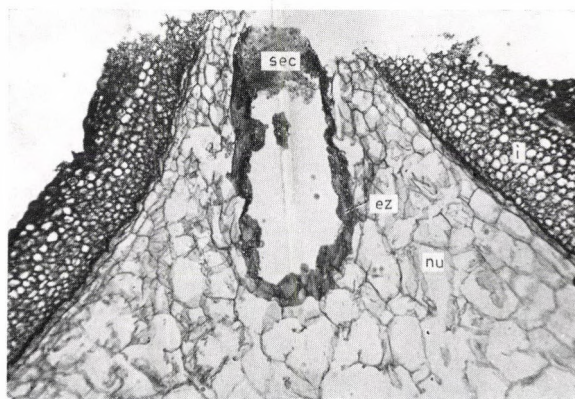


Fig. 49. Segregated cytoplasm in the micropylar end of the embryo sac. $\times 150$. Photo Zs. HATTYÁR-HIDAS

such as the pit-hole cell wall thickening appearing in the epidermal cells of the outer integument, and there are a great number of vascular bundles in the outer integument tissue.

The micropyles have closed by touching the apex of the inner integument, but the outer ones are still open. The nucellus is large and contains a small embryo sac; both are surrounded by the double integument. The length ratio between the embryo sac and nucellus is 15 : 340 consequently, only 4% of the ovary hole is filled with the embryo sac. In the embryo sac some free endosperm nuclei have developed beneath the zygote. The nucellus increased in size due to the appearance of a group of cells at the chalazal end and an almost continuously single marginal cell row (Fig. 31). The nucellus cells are isodiametric, thin walled, and large except those which are in the dividing stage.

The multiplying cell group of the nucellus at the chalazal end in the *Prunus cerasifera* was identified as hypostase by CZOSNOWSKI (1966). The nucellar origin of the hypostase was established by SCHULZ and JENSEN (1971) in the *Capsella pursa-pastoris* and by SZUJKÓ-LACZA

(1978) in some Umbelliferae species. Hypostase can function as an enzyme producing gland and its product is directly introduced into the embryo sac (cf. SZUJKÓ-LACZA 1978). The basal cells of the nucellus function as a tissue increasing group in the subfamily Prunoideae and these cells are situated far from the embryo sac during the long developing period. More probably they are not hypostase cells. We often can find 14–15 mm long fruits, the style has

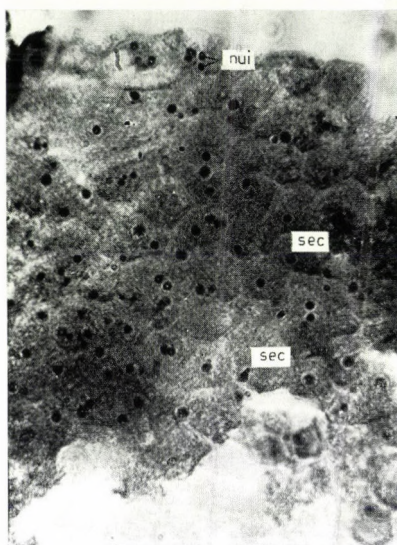


Fig. 50. Separated cytoplasm with one or more nuclei in one cytoplasm "unit". $\times 750$. Photo Zs. HATTYÁR-HIDAS

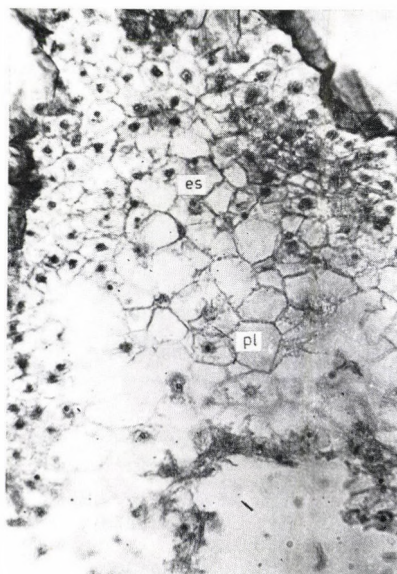


Fig. 51. Secondary endosperm with the membrane-like cell walls. $\times 730$. Photo E. B. SZIKSZAY

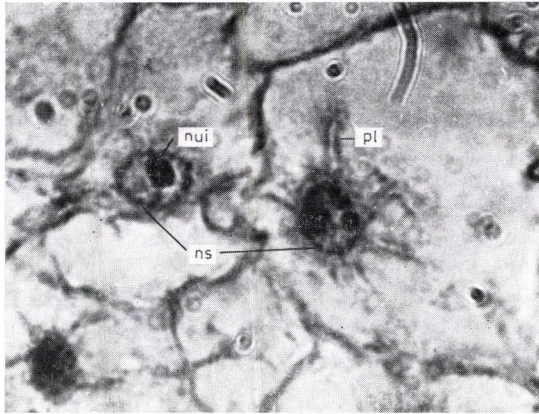


Fig. 52. Secondary endosperm cells differ in size and the number of nucleoli. $\times 1400$. Photo Zs. HATTYÁR-HIDAS



Fig. 53. Nucellus and the secondary endosperm tissue. $\times 300$. Photo E. B. SZIKSZAY

dried the cell wall thickens in the style basal cells (Fig. 35), which remain as the style point in the ripened fruit.

Cell division and cell growth are profuse in the peri- and in the endocarp, too. The direction of cell division results in a "parquet-like" or "fish-bone" arrangement in the endocarp cells (Fig. 36). Differentiation and the wall thickening process are continuous in the epidermis of the outer integument. The nucellus increased in size as mentioned above, followed by the cell division in the zygote. The free endosperm nuclei are distributed around the embryo and parietale in the embryo sac. Most of the nuclei have only one nucleolus (Fig. 37) except those nuclei which are in the vicinity of the embryo. Here the number of nucleoli is variable in one nucleus and both show a variety in form. Moreover, a "dark-hill" emerges from the granulated

cytoplasm. They are the first signs of the beginning of the vesiculation process (Fig. 38). In other embryo sacs there are before numerous vesicles around the embryo (Fig. 39). The position of the free endosperm nuclei seems to be irregular among the vesicles (Fig. 40).

Fruits are 16–18 mm long. The cell wall thickening is prominent and the nucleus still exists in the longer and shorter hair cells also in the exocarp. The latter comprises from three to four cell rows. Phloem and transfer cells are dominant in the vascular bundles of the pericarp. As a consequence of the wall thickening process these cells are characteristic in the apical part of the outer integument (Fig. 41). Redifferentiation and sclerification of the outer integument's epidermis were studied first by BERNSEN (1966). Starch is deposited in these epidermal and subepidermal cells (Fig. 42). Expansion and lysis of the different nucellus cells happened parallel (Fig. 43). The number of vesicles increased in the embryo sac.

In the 18–19 mm long fruit the epidermal cells of the outer integument being green, were stained with toluidine blue. The spherical embryo has some suspensor cells in the sand-glass-like embryo sac (Fig. 44). Vesicles grouped beneath the embryo begin the union of the small vesicles to larger ones which infiltrate the central vacuole (Fig. 45). The membrane of the vesicles is bound up in the tonoplast of the central vacuole.

In 20 mm or longer fruits the endospermal vesicles are in the middle of the embryo sac or they reach the chalazal end. The distribution of free endosperm nuclei and their size show a certain arrangement (Fig. 37) before vesiculation and this pattern almost disappears during the vesiculation process (Fig. 45). The behaviour of the 256 free endosperm nuclei in the embryo sac of the apricot was investigated cytomorphologically and quantitatively.

As shown in Table 1 the distance between two nuclei is $13\text{ }\mu\text{m}$, the diameter of the nucleus is $9.9\text{ }\mu\text{m}$ and nucleoli have a mean diameter of $4.7\text{ }\mu\text{m}$. The volume of the nucleus is $461.9\text{ }\mu\text{m}^3$ in the separated cytoplasm and $104.1\text{ }\mu\text{m}^3$ before cytoplasm separation. Thus 22.54% of the nucleoli volume is from the nucleus. The cytoplasm "unit" has a volume of

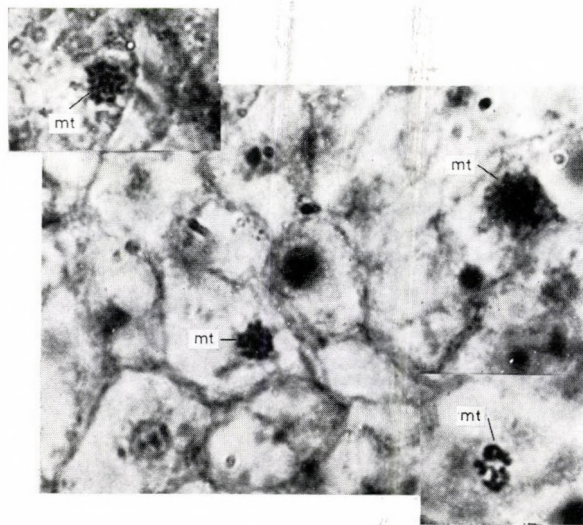


Fig. 54. The number of chromosomes differs in the secondary endosperm cells. $\times 1400$. Photo E. B. SZIKSZAY

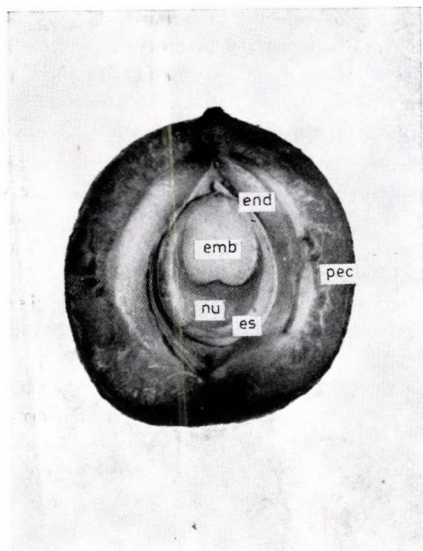


Fig. 55. Longitudinal section of the fruit parallel with the raphe. Photo I. RÁCZ



Fig. 56. Ovule cross-section above the chalazal end of the embryo sac. $\times 115$. Photo E. B. SZIKSZAY

approximately $2170.2 \mu\text{m}^3$; the nucleus is $638.2 \mu\text{m}^3$ and the nucleoli $461.9 \mu\text{m}^3$. Thus 29.4% of nucleoli volume is from the nucleus in that case.

Consequently, the difference in nucleus volume between the relative homogenous and in the separated cytoplasm is $176.3 \mu\text{m}^3$ to the advantage of the separated cytoplasm. This difference increases to $376.6 \mu\text{m}^3$ if the separated cytoplasm contains more than one nucleoli. In other words the volume of the nucleus increases by 27.62% and that of the nucleoli by 21.66% in the separated cytoplasm compared with the former state. The minimal distance between two nuclei was $7.5 \mu\text{m}$ (in two cases) while the maximum distance was $25.2 \mu\text{m}$ (in three cases). The smallest nucleus diameter was $7.5 \mu\text{m}$ (in two cases) while the largest was $12.5 \mu\text{m}$ (in six cases). The diameter of the nucleoli varied from $3 \mu\text{m}$ (in one case) to $6.3 \mu\text{m}$

(in five cases). The smallest nucleus diameter was $5\ \mu\text{m}$ while the longest $12.5\ \mu\text{m}$; those of the nucleoli were $1\ \mu\text{m}$ and $7.5\ \mu\text{m}$, respectively, in separated cytoplasm. Two or more nucleoli were found in one nucleus in 18.5% of the examined area in the separated cytoplasm.

The union of the nucleus and nucleoli can be studied using cytomorphic and metric characters (Figs 38, 46, 47, 48 and Table 1) before and after vesiculation (Fig. 46) stage in the embryo sac. Nucleus deformation often can be seen before the fusion (Figs 38, 47, 48) when the two nuclei are situated relatively far from each other. However, this modification in form

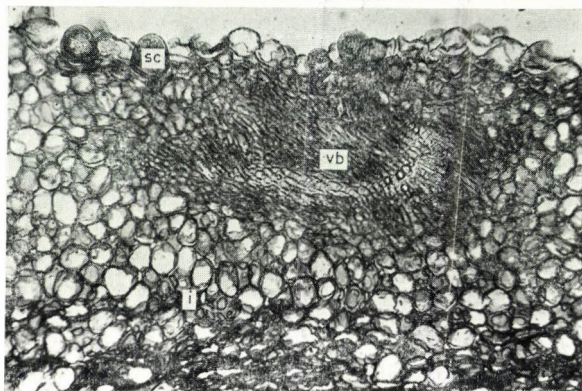


Fig. 57. Vessel in the integument parallel with the ventral suture. $\times 290$. Photo E. B. SZIKSZAY



Fig. 58. Cross-section of the ovule. $\times 290$. Photo E. B. SZIKSZAY

Table 1*Measurement data for cytoplasm,
nuclei and nucleoli before separation*

Nucleus diam., μm	Nucleolus diam., μm	Distance between two nuclei, μm
12.0	5.0	12.5
10.0	3.0	10.0
10.0	5.0	7.5
12.5	5.0	15.0
12.5	5.0	9.0
10.0	3.5	9.0
7.5	2.5	9.0
9.0	4.0	10.0
10.0	4.0	9.0
12.0	5.0	10.0
10.0	4.0	10.0
12.5	5.0	10.0
10.0	4.0	7.5
10.0	4.0	9.0
10.0	5.0	11.0
11.5	5.0	10.0
7.5	4.0	12.5
10.0	4.0	12.5
12.5	5.0	12.5
10.0	4.0	12.5
9.5	5.0	25.2
12.5	6.3	25.2
12.5	6.3	22.0
9.5	6.3	22.0
6.3	5.0	25.2
9.4	6.3	12.6
9.4	6.3	12.6
$\Sigma = 266.6$	$\Sigma = 126.2$	$\Sigma = 349.9$
$\bar{x} = 9.9 \mu\text{m}$	$\bar{x} = 4.7 \mu\text{m}$	$\bar{x} = 12.96 \mu\text{m}$

happens well after the two nuclei are in contact. Union of the nuclei usually results in an increase in size. Fusion of the nucleoli ensures somewhat later than nucleus union (Figs 38, 46, 47, 48). The fusion of nucleoli varies in form (Figs 38, 48). During the union process the cytoplasm is granular. The nuclear membrane usually doubles after the union of the nucleoli (Fig. 48).

The vesiculation process is not equal in intensity in the different embryo sacs. In some instances the union of nucleoli and nucleus and separation of the cytoplasm take place with a weak vesiculation (Fig. 38) while the endospermal vesiculation may be very vigorous in other cases in the embryo sac (Figs 39, 40, 45). The union of the nucleus and separation of the cytoplasm are interchangeable depending on the distance from the embryo. The proximity of the embryo induces the separation of the cytoplasm (Figs 49, 50). A membrane-like cell wall forms round the cytoplasm soon (Fig. 51). Fusion of the nucleus and the nucleolus takes place

Table 2

*The cytoplasm, nuclei and nucleoli after separation
of the cytoplasm*

Cytoplasm "unit" diam., μm	Nucleus or nuclei diam., μm	Nucleoli diam., μm
20.0	7.5	4.0
20.0	11.5	4.0; 2.5
30.0	10.0	4.0
32.5	10.0; 7.5	4.0; 3.0; 4.0
20.0	10.0	4.0; 4.0; 2.0
17.5	10.0; 7.5	5.0; 4.0; 2.5
20.0	10.0; 7.5	5.0; 2.5; 1.0
22.5	10.0	7.5
22.5	10.0	5.0
20.0	7.5	5.0
22.5	7.5	5.0
17.5	10.0	5.0
22.5	7.5	5.0
25.0	12.5	5.0; 3.0; 2.5; 2.0
25.0	10.0	5.0
22.5	10.0	6.5; 2.5
15.0	10.0	5.0
20.0	10.0	5.0
15.0	7.5	4.0
15.0	7.5	2.5; 2.5
20.0	7.5; 7.5; 7.5	4.0; 4.0; 4.0
20.0	7.5; 7.5	4.0; 4.0
20.0	10.0; 7.5	5.0; 4.0
22.5	7.5; 5.0	4.0; 4.0
17.5	7.5; 7.5	4.0; 4.0
17.5	7.5; 7.5	4.0; 4.0
<hr/>		
$\Sigma = 704.5$	$\Sigma = 318.0$	$\Sigma = 186.5$
$\bar{x} = 174.2$	$\bar{x} = 11.5$	$\bar{x} = 6.9$

only in the separated cytoplasm near the embryo. These new secondary endosperm cells are frequently highly vacuolised. The great number of nucleoli and variation in their shape may be connected with the synthesis of ribosomal RNA, as in many other cases (cf. ESAU 1967). The ultrastructure of the nucleoli was clarified by JOHNSON (1969).

The free endosperm nuclei show variability in size (Table 1). The number of fusionated nuclei and nucleoli is usually different in cells next to each other (Figs 38, 46, 47 and Table 2) in the apricot.

A variable number of polyploidy in the secondary endosperm cells is a well-known fact (cf. MAHESHWARI 1950) which is due to the fusion of the nucleus and nucleoli (SZUJKÓ-LACZA 1976). The sizes of both cells and nuclei and the number of nucleoli differ (Figs 51, 52) after union. The nucleus is larger in ploidity and has numerous plasma bridges (Figs 51, 52). The secondary endosperm cells are smaller and as a result the cell density increases along the embryo sac being the greatest in the centre (Fig. 53).

Mitosis begins in the cells situated near the embryo sac. The number of chromosomes varies depending on the number of nuclei united before in the different endosperm cells (Fig. 54). The endospermal vesiculation, separation of the cytoplasm, and cell wall formation always begins near the embryo and goes towards the chalazale end.

BRANDBURY (1929) observed the cellular endosperm cells near the embryo and nucellar ones at the chalazal end in *Prunus cerasus*. TURKEY (1933) obtained the same results in *Prunus avium*. Transformation of the nucellare to the cellular endosperm is usually complete in *Armeniaca vulgaris*.

The secondary endosperm cells absorb the nucellus — except for the simple first row of the marginal layer — by the process of cell division, cell growth (Figs 55, 56, 58) and by filling the space enclosed with the integuments. Sclerification of the epidermal cells of the outer integument is characteristic (Figs 56, 57, 58) and this cell row remains in the seed coat, too. Forming the first cells of the secondary endosperm, the median integumentary vascular bundle has developed up to now (Fig. 57). Secondary endosperm cells have remained only in the chalazal end of the embryo sac for a long time (Fig. 56) because the developing embryo

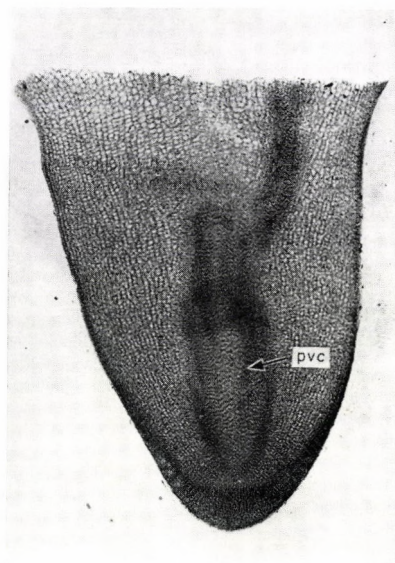


Fig. 59. Radicle with procambial vessel. $\times 115$. Photo E. B. SZIKSZAY

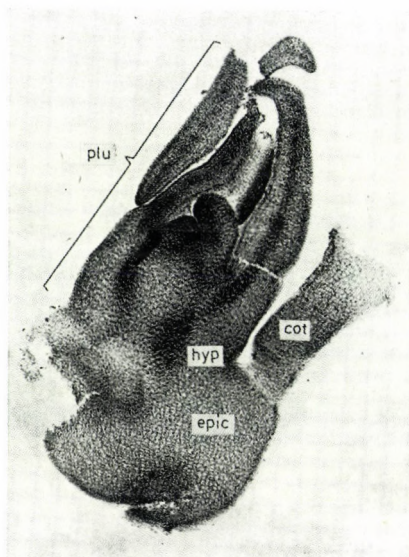


Fig. 60. Plumule. $\times 115$. Photo E. B. SZIKSZAY

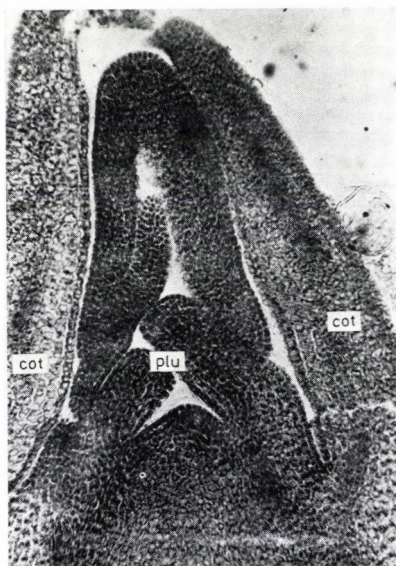


Fig. 61. The nutrient stored cotyledons and plumule in the seed. $\times 730$. Photo E. B. SZIKSZAY

absorbs them in the opposite apex (Fig. 58). After dissolution of the endosperm tissue the embryo fills up the space. The embryo comprises the radicle (Fig. 59), cotyledons and the shoot apex (Figs 60, 61) with procambium in it. Development of the seed and disappearance of the integuments occur concurrently. The remaining and collapsed cell walls of the integuments and the sclerified epidermis cells of the outer integuments are the seed coat composed of

several layers according to NYUJTÓ and TOMCSÁNYI (1959). The membrane-like inner layer is the embryo sac and the outer one originates from the crushed integuments. The sclerified cell row of the seed coat is assorted with the inner side of the stone fruit.

The nutrient storage tissues are the cotyledons containing starch grains at first and then oil drops in cells 50–60 days after blossoms according to RADIONENKO (1963a). The cotyledons and the shoot apex are filled with nutrients mainly with starch and oil together in the ripened seed.

The structure of the seed coat and stone fruit were investigated by PÉCHOUTRE (1902), BRADBURY (1929), PÉNZES (1957), KANIEWSKI (1963), BERNSEN (1966), MORLOVA et al. (1972) and BACIU (1977) in detail. KANIEWSKI studied the differentiation of both sides of the ovary wall (endo- and pericarp). Accordingly, the lignification of the sclereid cell groups occurs on the ventral side of the "stone" fruit in the blossoming time. BERNSEN (1966) observed the cytomorphological change of the sclereids.

The stone or hard fruit of *Armeniaca vulgaris* has five layers based on the shape and size differences of sclereids. The outer layer contains brachysclereids, the next is similar in cells but alters under light refraction compared to the first one. Macrosclereids develop in the third and fourth layers but in the latter the cells are cavernulous in the pith. Cell sizes in the third layer can reach 88×85 , or $153 \times 15 \mu\text{m}$. Isodiametric cells compose the fifth layer, they have ramiform pits (cf. PÉNZES 1957). Sclerification of the endocarp begins when the cells become white in colour but are soft enough. This process appears after a long time of blossoming according to my observations. These cells remain small (Figs 23, 30) and the forming of the endocarp begins with their elongation. Beside sclereids druse crystals also appear in this tissue (cf. BERNSEN 1966) which was characteristic of the pericarp layer earlier.

MORLOVA et al. (1972) studied it in relation to the endocarp in both subfamilies of Rosaceae. Results of their studies show that in species belonging to the Pomoideae subfamily the endocarp tends to parenchymatization, and in others belonging to Prunoideae to lignification for a better seed protection.

The pericarp is green and rich in vascular bundles and druse crystal idioblasts are to be found also in this tissue of the young fruit. The chloroplasts become chromoplasts during maturation. The colour becomes red on the side of the fruit which faces direct light and yellow on the other side facing diffuse light. Phloem and xylem parenchyma and transfer cells dominate in the vascular bundle of the pericarp. Vascular bundles are denser in the outer part of the mesocarp and less dense in the inner part as stated by BORBÁS (1880). The net-like vascular bundle system (Fig. 27) shows the greatest density next to the stone fruit — exocarp — and becomes less dense beneath the epidermis (Fig. 55). Druse crystal idioblasts persist in the mature pericarp, too. The exocarp of the fruit is several cell rows thick and it is covered with hairs (Fig. 25). Helical (spiral) thickenings of the primary tracheal elements of xylem remain in the pericarp during maturation.

Summary

Our observations reveal that filaments and pollen grains develop almost entirely in the bud (Figs 3, 10). Micro- and macrosporogenesis occur far from each other in time. The stigma exudes a liquid on the surface after double fertilization in the embryo sac.

Germinate pollen grains are to be found on the stigma surface in the liquid, and pollen tube(s) in the micropyle completing fertilizations (Figs 33, 34). Following the development, growth and lysis of the nucellus we can

find a cell group at the chalazal end (Fig. 43) and a single cell row (Fig. 31) at the margin (next to it the inner side of the inner integument) from which the nucellus increases in size. Growth and lysis of the nucellus take place parallelly and accelerate during the division of the zygote and free endosperm nuclei. The embryo sac is ovate at the beginning and is like a sand-glass at the end of the free endosperm nuclei phase.

Endospermal vesiculation is usually very prominent (Figs 39, 40, 44, 45). Vesicles become unified into larger vesicles (Fig. 40) and further increase the central vacuole (Fig. 45) with their content and with their membrane bound in the tonoplast.

The 256 free endosperm nuclei developed and the union of nuclei and nucleoli took place in varying numbers (Figs 38, 46, 47, 48, 50). The first cell division appears in the secondary endosperm cells near the embryo sac. The number of chromosomes varies in different endosperm cells depending on the number of free endosperm nuclei that have fused earlier. The growth of the nucellus finished by the time of the formation of the first secondary endosperm cells. Lysis began with the developing of the embryo sac and ended when all of the secondary endosperm cells had developed (Fig. 56). The cell content of the integuments has transferred to the nucellus and endosperm, but the crushed cells remained as seed coat.

The free endosperm nuclei and cytoplasm, and later on the secondary endosperm tissue, absorbed the whole nucellar tissue except for the single marginal cell row (Fig. 58). The secondary endosperm and the continuously decreasing nucellar tissue coexisted during the development of the embryo (Fig. 55). The embryo was surrounded by free endosperm nuclei (Figs 39, 44) and later by the secondary endosperm (Figs 55–58). The embryo absorbed food material from the integuments first by the suspensor cells and then directly from the secondary endosperm cells. Absorption of the endosperm was complete. Due to the absence of nutritive tissue (endosperm) in the seed, the embryo itself became a nutrition reserve (Figs 60, 61) for germination.

The pericarp can share in the assimilation process by the chloroplast containing cells for a long time. Xylem cells thickened only (Fig. 27) in the pericarp. This and the almost complete lack of fibres in the vascular bundle embedded in the thick parenchymatic tissue structurally confirmed the development of the edible fleshy pericarp.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the help of Miss Mary GREGORY in providing source of the literature; thanks are due to Mr. Dezső SURÁNYI for collecting the plant parts, and Mrs. Zsuzsanna HATTYÁR-HIDAS and Elisabeth B. SZIKSZAY for their technician help.

REFERENCES

- Baciu, E. (1970): Modificări anatomice în mugurii floriferi ai unor Prunoideae, înainte și în timpul repausului biologic (Anatomical modifications in the floriferous buds of some Prunoideae before and during the biological dormancy). *Lucr. Ses. știint. Inst. agron. Nicolae Bălcescu* **13**: 201–207.
- Baciu, E. (1971): Contribuții la studiul microsporogenezei la unele specii din subfamilia Prunoideae (Contributions to the study of microsporogenesis with some species of the family Prunoideae). *Lucr. Ses. știint. Inst. agron. Nicolae Bălcescu* **14**: 241–245.
- Baciu, E. (1972): Contribuții la studiul macrosporogenezei și formării sacului embrionar la câteva specii de Prunoideae (Contributions to the study of macrosporogenesis and embryo sac formation in some Prunoideae). *Lucr. Ses. știint. Inst. agron. Nicolae Bălcescu* **15**: 251–255.
- Baciu, E. (1977): Dezvoltarea embrionului la unele Prunoideae condițiile stationale din București. *Contr. Bot.* **20**: 223–225.
- Berezenko, N. P. (1966): O svolah differentsii tsvetkovy pochek chereschni i abrikosa. *Sadov. Vinogr. Vinod. Mold.* **21**: 53–56.
- Bernsen, G. (1966): Nogle karakteristika hos Kerner af *Prunus* Arter (Einige charakteristische Merkmale der Kernen in einigen *Prunus* Arten). *Dansk. Tidsskr. Farm.* **40**: 104–116.
- Bespechal'naya, V. V. (1967): Osobenosti tsvetnitsy i zavvazyvaniya plodov abrikosa v usloviyah Moldovii. *Sadov. Vinogr. Vinod. Mold.* **22**: 14–17.
- Borbás, V. (1880): Adatok a leveses (húsos) gyümölcsök szövettani szerkezetéhez [Beiträge zur histologischen Struktur der saftigen (fleischigen) Früchte]. *Bot. Zbl.* **42–43**: 1299–1303.
- Bradbury, D. (1929): A comparative study of the developing and aborting fruits of *Prunus cerasus*. *Am. J. Bot.* **16**: 525–542.
- Brózik, S., Nyéki, J. (1975): *Gyümölcstermő növények termékenyülése* (Fertilization of the fruit producing plants). Mezőgazdasági Kiadó, Budapest.
- Czosnowski, E. (1966): Badania embriologiczne nad przedstawicielami podroziny Prunoideae (preglad literaturey). *Wiad. Bot.* **10**: 189–208.
- Dorsey, M. J., Potter, J. S. (1932): A study of the structure of the skin and pubescens of the peach in relation to brushing. *Bull. Ill. agric. Exp. Stn.* **385**: 407–424.
- Esau, K. (1977): *Anatomy of Seed Plants*. 2nd Ed., Wiley and Sons, New York, Santa Barbara, London, Sydney, Toronto, pp. 550.
- Fahn, A. (1979): *Secretory Tissues in Plants*. Academic Press, London, New York, San Francisco.
- Gulyás, S. (1975): A méhlegelő növényei (The plants of honey-bee pasture). In: Halmágyi, L., Keresztesi, B. (eds): *A méhlegelő* (Honey-bee pasture). Akadémiai Kiadó, Budapest, pp. 22–24, 57–85.
- Hillman, A. (1910): Vergleichend-anatomische Untersuchungen über das Rosaceenhyphant. *Beih. Bot. Zbl.* **26**: 377–421.
- Iliev, I. (1963): Study on the differentiation and development of flower buds of some varieties of apricots in the Plovdiv region. *Izv. Akad. Selskostop. Nauki. Gradinarska Lozarska Nauka* **4**: 13–21.
- Johnson, J. M. (1969): A study of nucleolar vacuoles in cultured tobacco cells using radioautography, actinomycin D and electron microscopy. *J. Cell. Biol.* **43**: 197–206.
- Kaniewski, K. (1963): Badania porownawcze nad rozwojem endocarpu różnych gatunków roślin wytwarzających owoce pestkowce (Comparative investigations on the development of the endocarp of different species of drupaceous fruits). *Roczn. Sekc. dendrol. pol. Tow. bot.* **17**: 5–45.
- Lott, R. V., Simons, R. K. (1964): Floral tube and style abscission in the peach and their use as physiological reference points. *Proc. Am. Soc. Hort. Sci.* **85**: 141–153.
- Lott, R. V., Simons, R. K. (1968): The developmental morphology and anatomy of floral-tube and style abscission in the "Wilson Deliciosus" apricot (*Prunus Armeniaca* L.). *Hort. Res.* **8**: 67–73.
- Maheshwari, P. (1950): *An Introduction to the Embryology of Angiosperms*. McGraw-Hill, New York.
- Molnár, L., Stollár, A. (1971): Relation of flowering to temperature in Hungarian apricot. *Acta Agron. Hung.* **20**: 47–53.
- Morlova, I., Ūrsu, T., Marin, J. (1972): Contribuții carposemenologice privind unele specii de Rozaceae (Contribution to the carpel and seed knowledge in some Rosaceae). *Lucr. Ses. știint. Inst. agron. Nicolae Bălcescu* **15**: 195–202.
- Morlova, I., Marin, J., Baciu, E. (1977): Studiul anatomic al fructelor și semintelor unor specii din subfamiliile Rosoideae și Prunoideae. *Lucr. Ses. știint. Inst. agron. Nicolae Bălcescu* **17**: 76–82.

- Nyéki, J., Brózik, S., Ifjú, Z. (1974a): Egyes meggyfajták ivarszerveinek funkcióképessége (Activity of the sexual organs in some sour-cherry cultivars). *Bot. Köz.* **61**: 103–107.
- Nyéki, J., Brózik, S., Ifjú, Z. (1974b): Meggy- és cseresznyefajták klónjai virágnyílásának indukált periódicitása (Induced periodicity of the flowering of sour and sweet cherry clones and cultivars). *Bot. Köz.* **61**: 109–112.
- Nyéki, J., Ifjú, Z. (1975): Meggyfajták és klónok virágzásdinamikája (Blossoming dynamics by sour-cherry varieties and clones). *Bot. Köz.* **62**: 271–285.
- Nyujtó, F., Tomcsányi, P. (1959): *A kajszibarack és termesztése* (Apricot and its cultivation). Mezőgazdasági Kiadó, Budapest, 330 pp.
- Nyujtó, F., Banai, B.-né (1974): A Pándy meggy virágzásmenetének “mikrofenológiája” (Microphenological process of the Pándy sour-cherry). *Gyümölcsstermesztés* **1**: 175–190.
- Nyujtó, F., Banai, B.-né (1975): Előzetes közlemény a kajszibarack fajták termőrügyei téli morfogenezisének vizsgálatáról (Preliminary report from the observation of winter-morphogenesis of the reproductive buds of the different apricot convarieties). *Gyümölcsstermesztés* **2**: 15–21.
- Pant, D. D. (1965): On the ontogeny of stomate and other homologous structures. *Pl. Sci. Ser. Allahabad*. **1**: 1–24.
- Pate, J. S., Gunning, B. E. S. (1972): Transfer cells. *A. Rev. Pl. Physiol.* **23**: 173–196.
- Péchoutre, F. (1902): Contribution à l'étude du développement de l'ovule et de la graine des Rosacées. *Annals. Sci. nat. Bot. ser.* **8** (16): 1–158.
- Pénzes, A. (1957): Prunusok csontthéj (putamen) anatómiája [Die Stein (putamen)-anatomie einiger Prunus-Arten]. *Kertész. Kut. Int. Évk.* **2**: 249–259.
- Péter, J. (1975): Kajszi (*Armeniaca vulgaris* Lam.) [Apricot (*Armeniaca vulgaris* Lam.)]. In: Halmágyi, L., Keresztesi, B. (eds): *A méhlegelő* (Honey-bee pasture). Akadémiai Kiadó, Budapest.
- Radionenko, A. Y. (1963a): Do pitanja pro fiziologo-biokhimichni zimini v period embrionalnogo rozvitky abrikosa (On physiologic-biochemical changes in the period of embryonic development of the apricot). *Ukr. Bot. Zh.* **20**: 25–32.
- Radionenko, A. Y. (1963b): Deyaki sposterezheniya nad embriologiyu abrikosa zvichaynovo (*Armeniaca vulg.* Lam.) (Some observations on the embryology of *Armeniaca vulgaris* Lam.). *Ukr. Bot. Zh.* **20**: 15–23.
- Robbins, W. W., Ramaley, F. (1933): *Plants Useful to Man*. McGraw-Hill (Blakiston), New York.
- Ruehle, K. (1924): Beiträge zur Kenntnis der Gattung *Prunus*. *Bot. Arch.* **8**: 224–249.
- Schulz, P., Jensen, W. A. (1971): *Capsella* embryogenesis: The chalazal proliferating tissue. *J. Cell. Sci.* **8**: 139–163.
- Simons, R. K. (1969): Fruit tissue injury in apricots, *Prunus armeniaca* L. and sweet cherries, *Prunus avium* L., as a result of a late spring freeze. *J. Am. Hort. Soc.* **94**: 466–470.
- Sholokhov, A. M. (1970): Anatomo-morfologicheskie osobennosti i zimostoykost' tsvetkovih pochet abrikosa. *Abrikos. "Ajastan"*, Jerevan.
- Sholokhov, A. M. (1972): Izuchenie morfogeneza tsvetkovih pochet v svyazi s sortoisпитaniem i selekciej kostochkovih na zimostojkost' (metodicheskie ukazaniya). *Pechatnij ceh otдела nauchnoj informacii*. Jalta, pp. 14.
- Spuljovij, V. Ju. (1973): Pro mikrosporangioenez i rozvitok cholovichovo gametofita v abrikosa (Microsporangium genesis and development of male gametophytes in apricots). In: Introdukcija ta aklimatizatsiya roslin na Ukrajin. *Vüp.* **6**., *Akad. Nauk Ukrain-skoj RSZR*, Kiev, 117–119.
- Sterling, C. (1964): Comparative morphology of the carpel in the Rosaceae, I. Prunoideae: *Prunus*. *Am. J. Bot.* **51**: 36–44.
- Samushia, M. D. (1970): Rezultaty tsitoembriologicheskovo izuchenija nekotarih sortov abrikosa (The results of a cytoembryological study of some varieties of apricot). *Soobshch. Akad. Nauk gruz. SSR*. **61**: 681–683.
- Szujkó-Lacza, J. (1976): Fertilization and fusion of free endosperm nuclei in *Pimpinella anisum* L. *Acta Biol. Hung.* **27**: 65–70.
- Szujkó-Lacza, J. (1978): Hypostase, embryonic sac and endosperm in *Anethum graveolens* L. and various families. *Acta Biol. Hung.* **29**: 255–271.
- Turkey, H. B. (1933): Embryo abortion in early ripening varieties of *Prunus avium*. *Bot. Gaz.* **94**: 433–468.
- Vassilyev, A. E. (1969): Submicroscopic morphology of nectary cells and problems of nectar secretion. *Bot. Zh. SSSR* **54**: 1015–1031.
- Vassilyev, A. E. (1971): New data on the ultrastructure of the cells of flower nectary. *Bot. Zh. SSSR* **56**: 1292–1306.
- Vaughan, J. G. (1970): *The Structure and Utilization of Oil Seeds*. Chapman-Hall Ltd., London.

SCREENING OF SOME COMMON INDIAN TREES FOR LEAF PROTEIN

A. K. SINGH

DEPARTMENT OF BOTANY, GORAKHPUR UNIVERSITY, INDIA

(Received: 20. September, 1982)

Sixty-five tree species belonging to twenty-two families of Dicotyledons from Gorakhpur and an adjoining area were surveyed during 1980-81 for protein extraction. Protein nitrogen, protein, total nitrogen, and ash were estimated in the leaf samples and leaf protein concentrate (LPC). The dry matter of leaf samples was also recorded and the percentage extractabilities of total nitrogen and protein nitrogen of LPC were calculated. The species surveyed were categorized into four groups on the basis of LPC extractability. Three main categories and four sub-categories were established on the basis of protein nitrogen extracted from leaf and LPC containing nitrogen of dry matter.

Introduction

There is no need to emphasize on the protein gap and increasing population. This gap has forced a responsibility on scientist and agriculturist to overcome the protein gap. There are so many aspects by which the workers are on the path of overcoming the calory need. Leaf protein is one of the sources which also contribute to solve this burning problem.

Up to this stage the tree flora has not received much attention by the workers. Very little work has been done on tree species along with other crop and wild herbs (BYERS 1961, VALLIDEVI et al. 1965). This investigation was undertaken in connection with work being done at Gorakhpur on the extraction and use of protein from leaves (S.C.S.I.R. Lucknow Project). The idea that the protein in leaves, when extracted, could form a valuable addition to the human diet is not new and so many workers have been done in this possibility during last fifty years (PIRIE 1957; BYERS 1971; SINGH 1974).

Experimental

1. Leaves

Most of the leaves of tree were obtained from Gorakhpur and its adjoining area, where the temperature was hot most of the period. The annual rainfall is high and the vegetation dense and luxurient. The leaves were collected throughout the period in a random way. The period of time, place of collection and condition of the plant were recorded.

2. Protein extraction from leaves

Two hundred g of leaves was homogenized with 600 ml double distilled water in a waring blender for 30 min and green homogenate was filtered through double layered muslin cloth to remove the fibrous material. The filtrate was transferred into an evaporation dish (2000 ml cap.) and 0.1 N-HCl was added slowly with constant stirring to give a final pH of 4.5. The protein was centrifuged at 3000 rpm from this acidified extract. The protein residue (crude protein) was washed with double distilled water and recentrifuged before heating for coagulation at 60 °C for 20 min. This coagulated protein was liophylized and washed with acetone. The residual acetone was finally removed by drying the material at 60 °C under vacuum (MORRISON and PIRIE 1961).

Table 1
Details of the collection of leaf samples

No.	Name of species	Common name	Place of collection	Age & stage of leaf	Month of collection
1	<i>Terminalia arjuna</i>	Arjun	Kushami forest	F	June
2	<i>T. bellerica</i>	Bahera	Bicchaia colony	Pof	July
3	<i>T. catappa</i>	Desbi Badam	Town Hall compound	F	March
4	<i>T. chebula</i>	Harra	Tilkonja forest	F	March
5	<i>Callistemon lanceolatus</i>	Bottle brush	Univ. garden	F	October
6	<i>Eucalyptus globulus</i>	Eucalyptus	Univ. garden	F	June
7	<i>Melaleuca leucodendron</i>	—	Univ. garden	F	February
8	<i>Psidium guajava</i>	Amrood	Lacchipur	Pof	July
9	<i>Syzygium cumini</i>	Jamun	Rly. colony	Prf	February
10	<i>S. heyneanum</i>	Kath jamun	Khorabhar	F	March
11	<i>Barringtonia acutangula</i>	Paniha	Domingarh	F	June
12	<i>Lagerstroemia parviflora</i>	Ashidh	Betiahata	F	April
13	<i>L. speciosa</i>	Gulchaman	Univ. campus	F	July
14	<i>Lawsonia inermis</i>	Mehendi	R. C. Church	Pof	November
15	<i>Punica granatum</i>	Anar	Rly. colony	Pof	February
16	<i>Carica papaya</i>	Papita	Univ. campus	F	May
17	<i>Alangium salvifolium</i>	Akola	Rajghat	F	April
18	<i>Adina cordifolia</i>	Haldu	Civil lines	F	June
19	<i>Anthocephalus cadamba</i>	Kadamb	Civil lines	F	May
20	<i>Gardenia latifolia</i>	Gandhraj	Govt. garden	F	June
21	<i>Mitragyna parvifolia</i>	Tikuli	Civil lines	Pof	September
22	<i>Wendlandia heynei</i>	—	Domingarh	F	April
23	<i>Xeromphis uliginosa</i>	Pendar	Tilkonja forest	F	April
24	<i>Ardisia solanacea</i>	Bhakmal	Ramgarh	Prf	April
25	<i>Madhuca indica</i>	Mahuwa	Govt. garden	Prf	March
26	<i>Manilkara hexandra</i>	Khirni	Employment exchange	Prf	October
27	<i>Mimusops elengi</i>	Maulshri	Govt. garden	Pof	September
28	<i>Nyctanthes arbor-tristis</i>	Har. singar	Rly. colony	F	September
29	<i>Alstonia scholaris</i>	Chatayan	Betihata	Prf	November
30	<i>Holarrhena antidysenterica</i>	Kurchi	Univ. garden	Prf	April
31	<i>Nerium indicum</i>	Kaner	Univ. campus	F	May
32	<i>Plumeria rubra</i>	Gulachin	R. C. Church	F	August
33	<i>Thevetia peruviana</i>	Yellow kaner	Univ. garden	Pof	October
34	<i>Strychnos nux-vomica</i>	Kuchla	Betiahata	F	February
35	<i>Cordia dichotoma</i>	Lasora	Ramgarh forest	F	January
36	<i>Ehretia laevis</i>	—	Domingarh	Prf	January
37	<i>Jacaranda mimosifolia</i>	—	Univ. campus	F	April
38	<i>Millingtonia hortensis</i>	—	Rly. colony	F	November
39	<i>Spathodea campanulata</i>	—	Univ. garden	F	March
40	<i>Tecoma stans</i>	—	Rly. colony	F	January
41	<i>Premna mucronata</i>	—	Civil lines	Prf	July
42	<i>Tectona grandis</i>	Sagon	Tilkonja forest	F	June
43	<i>Santalum album</i>	Chandan	Univ. garden	F	October
44	<i>Antidesma ghaesembilla</i>	—	Tilkonja forest	Pof	September
45	<i>Bischofia javanica</i>	Paniyala	Tilkonja forest	F	March
46	<i>Bridelia squamosa</i>	Khaja	Padribazar	F	August
47	<i>Drypetes roxburghii</i>	Putjev	Bicchia colony	F	March
48	<i>Embllica officinalis</i>	Awala	Bicchia colony	Prf	January
49	<i>Mallotus philippensis</i>	Rohini	Cemetery	F	October
50	<i>Ricinus communis</i>	Rendi	Rly. colony	Prf	March
51	<i>Trewia polycarpa</i>	Bahdol	Ambazar	Prf	October

(Table 1 continued)

No.	Name of species	Common name	Place of collection	Age & stage of leaf	Month of collection
52	<i>Holoptelea integrifolia</i>	Chilbil	Civil lines	F	February
53	<i>Trema orientalis</i>	Jangli	Rajghat	Prf	October
54	<i>Artocarpus heterophyllus</i>	Kathal	Bilandpur	F	February
55	<i>A. lakoocha</i>	Barahal	Civil lines	F	March
56	<i>Ficus benghalensis</i>	Bargad	Univ. campus	Prf	April
57	<i>F. racemosa</i>	Gular	Maniram	F	March
58	<i>F. religiosa</i>	Pipal	Pedleyganj	Prf	March
59	<i>F. virens</i>	Pakri	Betiahata	F	June
60	<i>Morus indica</i>	Shahtoot	Govt. garden	F	March
61	<i>Streblus asper</i>	Singhor	Surajkund	Prf	December
62	<i>Casuarina equisetifolia</i>	Jhau	Govt. garden	F	April
63	<i>Borassus flabellifer</i>	Tar	Bilandpur	F	March
64	<i>Cocos nucifera</i>	Nariyal	Town hall	F	January
65	<i>Phoenix sylvestris</i>	Khajur	Ambazar	F	March

Prf = Pre-flowering stage

F = Flowering stage

Pof = Post-flowering stage

3. Analysis

The dry matter of plants was determined by drying at $80 \pm 5^\circ\text{C}$ for 48 h. The total nitrogen and protein nitrogen of the leaf sample and LPC were determined by the micro-digestion method of DONEEN (1932) followed by SNELL and SNELL (1953) for colorimetric estimation. The ash value was estimated according to A.O.A.C. (1960). Per cent extractability of LPC and per cent extractabilities of protein nitrogen and total nitrogen of LPC were calculated by the formula given by SHARMA et al. (1975).

Results

Sixty-five tree species of twenty-two families (Combretaceae, Myrtaceae, Lecythidaceae, Lythraceae, Punicaceae, Caricaceae, Coronaceae, Rubiaceae, Myrsinaceae, Sapotaceae, Oleaceae, Apocynaceae, Loganiaceae, Ehretiaceae, Bignoniaceae, Verbenaceae, Santalaceae, Euphorbiaceae, Ulmaceae, Moraceae, Casuarinaceae and Palmae) were collected in an adjoining area of Gorakhpur at its different stages of flowering condition, i.e. pre-flowering, flowering and post-flowering. Plants were arranged according to the BENTHAM and HOOKER system and as much as possible the correct nomenclature were given as in the International Code of Botanical nomenclature. Common name, place of collection and month of collection are recorded in Table 1.

The results of the analysis of leaf protein concentrates and leaf samples are recorded in Table 2 for their dry matter, ash, total nitrogen, protein nitrogen and percentage extractability of LPC (g/100 g dry weight basis). The LPC were categorized into four groups on the basis of the percentage extractability of LPC.

Category A (LPC extractability more than 18%)

Only two plant species were found in this category. *Barringtonia acutangula* (Lecythidaceae) and *Madhuca indica* (Sapotaceae) yielded the maximum (18.15 and 20.67% respectively) amount of LPC.

Table 2

*Analysis of dry matter, ash, total nitrogen, protein nitrogen
and LPC extractability of the species under survey*

Species	Dry matter, %	Total N, DM (%)	Protein N, DM (%)	Protein, DM (%)	Ash, DM (%)	Extrac- tability of LPC (g/100 g dry weight)
<i>Terminalia arjuna</i> ^a	26.42	3.84	1.99	12.43	09.44	03.78
<i>T. bellerica</i> ^a	25.23	4.12	2.63	16.43	06.26	07.71
<i>T. catappa</i> ^a	29.67	3.65	2.96	18.50	08.84	05.88
<i>T. chebula</i> ^a	29.28	3.43	2.36	14.75	05.44	05.82
<i>Callistemon lanceolatus</i> ^e	55.16	1.36	0.73	04.56	04.48	04.32
<i>Eucalyptus globulus</i> ^a	32.25	1.86	0.96	06.00	06.82	02.01
<i>Melaleuca leucodendron</i> ^a	32.68	2.76	2.17	13.56	05.66	04.57
<i>Pisidium guajava</i> ^a	37.31	2.36	1.23	07.68	11.22	06.03
<i>Syzygium cumini</i> ^b	29.10	2.52	2.16	13.50	03.80	18.15
<i>S. heyneanum</i> ^a	46.24	2.26	1.42	08.87	05.66	04.57
<i>Barringtonia acutangula</i> ^a	12.24	1.30	0.96	06.00	03.81	18.15
<i>Lagerstroemia parviflora</i> ^a	23.17	3.43	2.68	16.75	08.66	05.79
<i>L. speciosa</i> ^d	34.86	2.96	1.36	08.50	11.34	03.35
<i>Lawsonia inermis</i> ^a	32.12	3.86	2.54	15.87	10.22	06.53
<i>Punica granatum</i> ^a	22.53	4.33	2.87	17.87	06.88	04.77
<i>Carica papaya</i> ^a	12.50	1.36	0.98	06.12	11.56	14.22
<i>Alangium salvifolium</i> ^b	29.10	4.86	2.13	13.31	10.26	06.48
<i>Adina cordifolia</i> ^e	48.77	2.57	1.10	06.87	04.64	04.64
<i>Anthocephalus caolamba</i> ^b	31.80	4.91	3.05	19.06	05.66	08.52
<i>Gardenia latifolia</i> ^a	26.25	2.74	1.56	09.74	10.44	05.44
<i>Mitragyna parvifolia</i> ^a	14.26	1.30	0.96	06.00	03.86	09.15
<i>Wendlandia heynei</i> ^b	19.37	3.77	2.39	14.93	09.52	08.79
<i>Xeromphis uliginosa</i> ^a	24.98	2.63	1.43	08.93	04.48	06.28
<i>Ardisia solanacea</i> ^a	21.63	1.42	0.93	05.81	09.82	14.59
<i>Madhuca indica</i> ^a	25.00	2.76	2.13	13.31	16.76	20.67
<i>Manilkara hexandra</i> ^b	32.67	3.49	2.17	13.66	11.34	07.63
<i>Mimusops elengi</i> ^a	28.36	2.16	1.96	12.18	08.52	05.36
<i>Nyctanthes arbor-tristis</i> ^a	34.28	2.86	1.39	06.86	10.40	14.03
<i>Alstonia scholaris</i> ^b	29.15	2.05	1.69	10.56	10.62	01.92
<i>Holorrhena antidysenterica</i> ^a	26.73	3.63	2.35	14.78	12.96	08.66
<i>Nerium indicum</i> ^a	35.35	4.33	3.76	23.50	14.32	05.39
<i>Plumeria rubra</i> ^a	18.88	4.56	3.10	19.37	10.20	10.63
<i>Thevetia peruviana</i> ^b	27.50	2.56	1.80	07.43	16.84	02.29
<i>Strychnos nux-vomica</i> ^a	28.62	2.32	1.99	12.43	08.52	07.35
<i>Cordia dichotoma</i> ^a	21.20	2.17	1.98	12.37	12.62	05.16
<i>Ehretia laevis</i> ^a	14.69	3.73	2.33	14.56	04.96	06.50
<i>Jacaranda mimosifolia</i> ^a	20.00	1.52	1.04	06.50	03.80	14.00
<i>Millingtonia hortensis</i> ^b	30.12	2.11	1.42	08.87	04.86	04.87
<i>Spathodea companulata</i> ^b	39.15	3.05	2.10	13.12	10.00	06.25
<i>Tecoma stans</i> ^d	34.20	2.46	1.30	08.12	08.04	09.23
<i>Premna mucronata</i> ^a	32.10	3.40	2.06	12.87	09.40	09.81
<i>Tectona grandis</i> ^d	40.17	2.57	1.67	10.43	09.44	09.21
<i>Santalum album</i> ^d	39.75	4.68	3.04	19.00	07.08	06.63
<i>Antidesma ghaesembilla</i> ^a	33.48	2.58	1.75	10.50	08.42	07.78
<i>Bischofia javanica</i> ^a	26.33	3.36	2.03	12.68	12.66	11.35
<i>Bridelia squamosa</i> ^e	62.20	2.84	1.68	10.50	13.20	05.13
<i>Drypetes roxburghii</i> ^d	41.32	2.84	1.09	06.81	10.82	04.39
<i>Embllica officinalis</i> ^e	47.17	1.83	0.97	06.06	15.44	07.25
<i>Mallotus philippensis</i> ^a	26.80	4.43	3.16	19.75	08.26	03.58
<i>Ricinus communis</i> ^c	25.00	3.84	2.30	14.37	05.24	01.92
<i>Trewia polycarpa</i> ^a	33.12	3.07	2.06	12.87	06.62	14.30
<i>Holoptelea integrifolia</i> ^a	16.35	1.36	0.73	04.76	08.34	12.31

(Table 2 continued)

Species	Dry matter, %	Total N, DM (%)	Protein N, DM (%)	Protein, DM (%)	Ash, DM (%)	Extrac- tability of LPC (g/100 g dry weight)
<i>Trema orientalis</i> ^a	22.73	2.44	1.94	12.12	11.76	09.94
<i>Artocarpus heterophyllus</i> ^a	33.19	2.53	1.16	07.25	14.22	05.57
<i>Artocarpus lakoocha</i> ^a	31.56	4.73	3.33	20.71	11.34	06.98
<i>Ficus benghalensis</i> ^d	33.21	2.16	1.96	12.25	07.66	05.45
<i>F. racemosa</i> ^d	32.00	3.98	2.26	14.13	20.20	04.37
<i>F. religiosa</i> ^e	53.13	2.33	1.47	09.18	20.62	03.72
<i>F. virens</i> ^d	44.15	2.76	1.71	10.68	12.24	00.61
<i>Morus indica</i> ^a	33.46	1.36	0.98	06.12	12.56	02.16
<i>Streblus asper</i> ^d	44.00	3.83	2.18	13.62	04.28	02.75
<i>Casuarina equisetifolia</i> ^a	38.37	2.83	2.05	12.81	10.76	05.39
<i>Borassus flabellifer</i> ^e	68.32	2.56	1.45	09.12	08.36	00.76
<i>Cocos nucifera</i> ^e	63.53	1.04	0.53	03.31	04.48	01.33
<i>Phoenix sylvestris</i> ^e	65.36	3.35	2.10	13.12	06.34	03.55

DM = dry matter; Protein = $6.25 \times$ protein N; ^a No mucilage, fibres minimum, mincing and extraction easy; ^b Slight mucilage present, no difficulty in extraction; ^c Highly mucilaginous, tough extraction; ^d Fiber rich, tough extraction; ^e Optimum fiber and extraction also tough.

Category B (LPC extractability between 12–18%)

Six plant species, viz., *Ardisia solanacea*, *Trewia polycarpa*, *Carica papaya*, *Nyctarthes arbortristis*, *Jacaranda mimosifolia* and *Holoptelia integrifolia* of six families, yielded 12–18% LPC.

Category C (LPC extractability, 6–12%)

Twenty-four tree species were noted their range of LPC in between 6–12% such as *Bischofia javanica*, *Plumeria rubra*, *Erythrina indica*, *Trema orientalis*, *Premna mucronata*, *Tecoma stans*, *Tectona grandis*, *Mitragyna parviflora*, *Wendlandia heynei*, *Holarrhena antidysenterica*, *Anthocephalus cadamba*, *Syzygium cumini*, *Antidesma ghaesembilla*, *Terminalia bel-lirica*, *Manilkara hexandra*, *Strychnos nux-vomica*, *Emblca officinalis*, *Artocarpus lakoocha*, *Santalum album*, *Lausonia inermis*, *Ehretia laevis*, *Xeromphis uliginosa*, *Spathodia campanulata* and *Psidium guajava*.

Category D (LPC extractability less than 6%)

Rest of the thirty-three species were placed in this category which show their LPC less than 6%, such as *Terminalia catappa*, *T. chebula*, *Lagerstroemia parviflora*, *Artocarpus heterophyllus*, *Ficus bengalensis*, *Gardenia latifolia*, *Casuarina equisetifolia*, *Nerium indicum*, *Mimusops elengi*, *Cordia dichotoma*, *Bridelia squamosa*, *Millingtonia hortensis*, *Punica granatum*, *Adina cordifolia*, *Syzygium heyneanum*, *Drypetes roxburghii*, *Ficus racemosa*, *Callistemon lanceolatus*, *Terminalia arjuna*, *Ficus religiosa*, *Mallotus phillippensis*, *Phoenix sylvestris*, *Melaleuca leucodendron*, *Lagerstroemia speciosa*, *Streblus asper*, *Morus indica*, *Eucalyptus globulus*, *Alstonia scholaris*, *Ricinus communis*, *Cocos nucifera*, *Borassus flabellifer* and *Ficus virens*.

Total nitrogen, protein nitrogen, protein and ash in DM of the leaf samples were found maximum in *Anthocephalus cadamba* (4.91%), *Nerium indicum* (3.76%), *N. indicum* (23.25%)

Table 3

Analysis of LPC and the extractability of total nitrogen and protein nitrogen

Species	Initial pH of extract	Analysis of LPC (dry weight basis)				Extractability, %	
		Total N, %	Protein N, %	Protein % $\times 6.25$	Ash, %	Total N	Protein N
<i>Terminalia arjuna</i>	6.1	3.95	2.89	18.06	11.00	03.88	01.95
<i>T. bellerica</i>	6.3	5.84	3.55	22.18	08.34	10.92	06.64
<i>T. catappa</i>	7.1	5.37	3.18	19.87	10.20	08.63	05.12
<i>T. chebula</i>	6.8	6.08	4.95	30.93	07.62	10.31	08.39
<i>Callistemon lanceolatus</i>	6.7	8.72	6.73	42.06	08.10	27.69	20.64
<i>Eucalyptus globulus</i>	5.6	4.50	2.62	16.37	10.44	04.86	02.83
<i>Melaleuca leucodendron</i>	6.9	4.88	3.16	19.75	08.18	06.07	03.93
<i>Psidium guajava</i>	6.0	6.43	4.61	28.81	17.20	16.42	11.77
<i>Syzygium cumini</i>	6.2	4.46	3.15	19.68	06.82	14.53	10.26
<i>S. heyneanum</i>	5.9	5.60	3.97	24.81	09.52	11.32	08.02
<i>Barringtonia acutangula</i>	6.9	2.64	1.68	10.50	06.84	36.89	28.45
<i>Lagerstroemia parvifolia</i>	7.2	6.18	4.06	25.37	10.32	10.43	06.85
<i>L. speciosa</i>	6.9	3.73	2.36	14.75	18.80	04.22	02.67
<i>Laesonia inermis</i>	6.3	4.26	3.08	19.25	14.12	07.26	05.25
<i>Punica granatum</i>	7.2	6.86	5.13	32.06	08.84	07.55	05.74
<i>Carica papaya</i>	6.4	2.24	1.58	09.87	13.54	23.42	17.25
<i>Alangium salvifolium</i>	6.8	8.56	6.88	43.00	16.40	11.41	09.11
<i>Adina cordifolia</i>	6.2	9.63	7.96	49.75	05.62	17.38	14.37
<i>Anthocephalus cadamba</i>	6.4	8.73	6.10	38.12	07.46	15.14	10.58
<i>Gardenia latifolia</i>	7.2	3.36	2.39	14.93	17.32	07.71	05.06
<i>Mitragyna parvifolia</i>	6.7	2.64	1.68	10.50	06.80	17.43	11.81
<i>Wendlandia heynei</i>	7.1	5.42	3.16	19.75	12.36	12.63	07.36
<i>Xeromphis uliginosa</i>	5.9	4.86	2.83	17.68	07.20	11.60	06.75
<i>Ardisia solanacea</i>	5.6	2.66	1.56	09.75	12.24	31.55	28.09
<i>Madhuca indica</i>	6.8	4.23	3.69	23.06	17.68	31.67	27.62
<i>Manilkara hexandra</i>	7.2	6.38	4.13	25.81	13.82	13.94	09.02
<i>Mimusops elengi</i>	7.0	5.62	4.04	25.65	10.26	13.54	10.05
<i>Nyctanthes arbor-tristis</i>	7.1	3.72	2.60	16.20	11.00	13.52	12.75
<i>Alstonia scholaris</i>	6.4	9.91	6.73	42.06	12.04	09.47	06.30
<i>Holarrhena anti-dysenterica</i>	6.8	6.94	5.08	31.75	13.12	15.17	12.11
<i>Nerium indicum</i>	6.3	9.25	7.16	44.75	15.24	11.51	08.91
<i>Plumeria rubra</i>	6.5	8.13	6.61	41.37	12.62	18.95	15.47
<i>Thevetia peruviana</i>	6.4	7.27	5.26	32.87	20.20	06.50	04.70
<i>Strychnos nux-vomica</i>	6.9	5.22	4.53	28.31	11.34	16.46	14.28
<i>Cordia dichotoma</i>	7.0	3.68	2.40	15.00	16.44	08.75	05.70
<i>Ehretia laevis</i>	6.7	5.84	4.17	26.06	06.16	10.37	07.26
<i>Jacaranda mimosifolia</i>	6.8	2.98	2.23	13.93	05.64	27.44	20.53
<i>Millingtonia hortensis</i>	7.2	4.63	3.12	19.50	08.16	10.16	07.20
<i>Spathodea companulata</i>	6.6	4.47	3.72	23.25	16.44	09.15	07.62
<i>Tecoma stans</i>	6.9	4.89	3.19	19.93	09.28	17.94	11.56
<i>Premna mucronata</i>	7.0	5.23	4.66	29.12	10.26	15.08	13.44
<i>Tectona grandis</i>	6.6	4.52	3.96	24.55	09.88	16.20	14.91
<i>Santalum album</i>	7.2	6.43	5.17	32.31	10.06	09.10	07.32
<i>Antidesma ghaesembilla</i>	7.1	4.86	3.32	20.75	09.88	13.04	10.01
<i>Bischofia javanica</i>	7.3	5.57	4.13	25.81	14.12	18.57	13.95
<i>Bridelia squamosa</i>	6.2	4.76	3.96	24.55	13.86	08.59	07.15
<i>Drypetes roxburghii</i>	5.8	7.96	5.26	32.87	18.40	12.33	08.13
<i>Emblica officinalis</i>	5.6	4.25	3.06	19.12	16.62	16.83	12.12
<i>Mallotus phillippensis</i>	5.8	6.46	5.16	32.25	11.24	05.45	04.16
<i>Ricinus communis</i>	7.2	8.00	6.60	41.25	07.82	04.00	03.30
<i>Trewia polycarpa</i>	5.7	7.54	5.36	33.30	07.08	35.12	28.22
<i>Holoptelea integrifolia</i>	7.3	3.27	2.86	16.75	10.54	28.59	24.25

(Table 3 continued)

Species	Initial pH of extract	Analysis of LPC (dry weight basis)				Extractability, %	
		Total N, %	Protein N, %	Protein % \times 6.25	Ash, %	Total N	Protein N
<i>Trema orientalis</i>	6.9	4.67	3.13	19.56	12.38	19.02	12.70
<i>Artocarpus heterophyllus</i>	6.2	5.13	3.69	23.06	16.42	11.29	08.91
<i>A. lakoocha</i>	6.7	6.54	4.96	31.00	12.64	09.65	07.02
<i>Ficus benghalensis</i>	6.6	5.62	4.10	25.62	10.82	13.25	10.34
<i>F. racemosa</i>	5.8	4.20	3.57	22.31	28.84	04.61	03.91
<i>F. religiosa</i>	6.8	9.46	7.29	45.56	21.28	15.10	11.63
<i>F. virens</i>	6.3	6.21	4.73	29.56	13.24	61.39	01.01
<i>Morus indica</i>	7.3	1.52	1.13	07.06	14.08	02.40	01.97
<i>Streblus asper</i>	5.8	5.96	4.77	29.81	06.82	04.28	03.68
<i>Casuarina equisetifolia</i>	7.0	4.46	3.20	20.50	12.36	08.46	06.24
<i>Borassus flabellifer</i>	7.2	4.83	3.47	21.68	11.64	01.43	01.03
<i>Cocos nucifera</i>	6.9	2.84	1.63	10.18	08.22	03.63	02.08
<i>Phoenix sylvestris</i>	7.2	5.56	4.12	25.75	15.20	05.89	04.46

and *Ficus racemosa* (20.20%), respectively. However, for the same perisuale the minimum values were noted in *Cocos nucifera*. In this species total nitrogen, protein nitrogen and protein show the lowest value, i.e., 1.04, 0.53 and 0.31%, respectively. Ash content was found minimum in *Jacaranda mimosifolia* (3.80%). The LPC extractability were found maximum in *Madhuca indica* (20.67%) and minimum in *Borassus flabellifer* (0.76%). Highest dry matter in leaf samples were recorded from *Borassus flabellifer* (68.32%) and lowest from *Barringtonia acutangula* (12.24%).

Table 4 indicates the categories of plants which were categorized on the basis of protein N extracted from the leaf and LPC containing nitrogen of dry matter (Categories IA, IB, IC and ID; IIA, IIB, IIC, IID and IIA, IIIB, IIIC and IIID).

Table 3 contains the initial pH of leaf juices, total nitrogen, protein nitrogen and ash percentages of LPC as well as the percentage extractabilities of total nitrogen and protein nitrogen. The pH of leaf extracts ranged 5.6 to 7.3. *Adina cordifolia* (9.63%) shows highest values of total nitrogen in LPC and *Morus indica* shows its lowest value of total nitrogen in LPC. Protein nitrogen and protein were also found maximum in *Adina cordifolia* (7.96 and 49.75%), respectively. Similarly *Morus indica* shows its lowest value for PN and protein (1.13 and 7.06%) respectively. The ash value ranged in between 5.62 to 28.84. *Barringtonia acutangula* shows their highest percentages extractabilities of total N and protein N (38.39 and 28.45) and *Ficus virens* shows its lowest value (1.39 and 1.01).

Discussion

The metabolic activity of the organism is directly related with the energy injected in the form of food or feed. In the previous paper a general survey was done for the evaluation of protein quantity in tree species under temperate climate. In this investigation trees were surveyed under the dry condition of Gorakhpur. The amount of leaf protein concentrate obtained per unit of leaf sample directly depends on the extractability of LPC. Several factors are known which affect the extractability of LPC, such as plant species, age of

Table 4
Categorization of the species under survey

Family	Species	Protein N extracted, %	Total N in dry matter of LPC, %
Category IA (more than 20% protein N extracted from the leaf and LPC containing more than 8% nitrogen of dry matter)			
Myrtaceae	<i>Callistemon lanceolatus</i>	20.64	8.72
Category IB (more than 20% protein N extracted from the leaf and LPC containing 6–8% nitrogen of dry matter)			
Euphorbiaceae	<i>Trewia polycarpa</i>	28.22	7.54
Category IC (more than 20% protein N extracted from the leaf and LPC containing 4–6% nitrogen of dry matter)			
Sapotaceae	<i>Madhuca indica</i>	27.62	4.23
Category ID (more than 20% protein N extracted from the leaf and LPC containing less than 4% nitrogen of dry matter)			
Ulmaceae	<i>Holoptelea integrifolia</i>	24.25	3.27
Lecythidaceae	<i>Barringtonia acutangula</i>	23.45	2.64
Bignoniaceae	<i>Jacaranda mimosifolia</i>	20.53	2.98
Category IIA (10–20% protein N extracted from leaf and LPC containing more than 8% nitrogen of dry matter)			
Apocynaceae	<i>Plumeria rubra</i>	15.47	8.13
Rubiaceae	<i>Adina cordifolia</i>	14.37	9.63
Moraceae	<i>Ficus religiosa</i>	11.63	9.46
Rubiaceae	<i>Anthocephalus cadamba</i>	10.58	8.73
Category IIB (10–20% protein N extracted from leaf and LPC containing 6–8% nitrogen of dry matter)			
Apocynaceae	<i>Holarrhena antidysenterica</i>	12.11	6.94
Myrtaceae	<i>Psidium guajava</i>	11.77	6.43
Category IIC (10–20% protein N extracted from leaf and LPC containing 4–6% nitrogen of dry matter)			
Verbenaceae	<i>Tectona grandis</i>	14.91	4.72
Loganiaceae	<i>Strychnos nux-vomica</i>	14.28	5.52
Euphorbiaceae	<i>Bischofia javanica</i>	13.95	5.57
Verbenaceae	<i>Premna mucronata</i>	13.44	5.23
Ulmaceae	<i>Trema orientalis</i>	12.70	4.67
Euphorbiaceae	<i>Embelica officinalis</i>	12.12	4.25
Bignoniaceae	<i>Tecoma stans</i>	11.56	4.89
Moraceae	<i>Ficus benghalensis</i>	10.34	5.62
Myrtaceae	<i>Syzygium cumini</i>	10.26	4.46
Sapotaceae	<i>Mimusops elengi</i>	10.02	5.62
Euphorbiaceae	<i>Antidesma ghaesembilla</i>	10.01	4.86
Category IID (10–20% protein N extracted from leaf and LPC containing below 4% nitrogen of dry matter)			
Caricaceae	<i>Carica papaya</i>	17.25	2.24
Oleaceae	<i>Nyctanthes arbor-tristis</i>	12.75	3.72
Rubiaceae	<i>Mitragyna parvifolia</i>	11.81	2.64
Myrsinaceae	<i>Ardisia solanacea</i>	10.09	2.66

(Table 4 continued)

Family	Species	Protein N extracted, %	Total N in dry matter of LPC, %
Category IIIA (less than 10% protein N extracted from the leaf and LPC containing more than 8% nitrogen of dry matter)			
Coronaceae	<i>Alangium salvifolium</i>	9.11	8.56
Apocynaceae	<i>Nerium indicum</i>	8.91	9.25
Apocynaceae	<i>Alstonia scholaris</i>	6.30	9.91
Category IIIB (less than 10% protein N extracted from the leaf and LPC containing 6–8% nitrogen of dry matter)			
Sapotaceae	<i>Sapindus mukorassi</i>	9.02	6.38
Combretaceae	<i>Terminalia chebula</i>	8.39	6.08
Euphorbiaceae	<i>Drypetes roxburghii</i>	8.13	7.96
Santalaceae	<i>Santalum album</i>	7.32	6.43
Moraceae	<i>Artocarpus lakoocha</i>	7.02	6.54
Lythraceae	<i>Lagerstroemia parviflora</i>	6.85	6.18
Punicaceae	<i>Punica granatum</i>	5.74	6.86
Apocynaceae	<i>Thevetia peruviana</i>	4.70	7.27
Euphorbiaceae	<i>Mallotus philippensis</i>	4.16	6.46
Euphorbiaceae	<i>Ricinus communis</i>	3.30	8.00
Moraceae	<i>Ficus virens</i>	1.05	6.21
Category IIIC (less than 10% protein N extracted from the leaf and LPC containing 4–6% nitrogen of dry matter)			
Moraceae	<i>Artocarpus heterophyllus</i>	8.91	5.13
Myrtaceae	<i>Syzygium heyneanum</i>	8.02	5.60
Bignoniaceae	<i>Spathodea companulata</i>	7.62	4.47
Rubiaceae	<i>Wendlandia heynei</i>	7.36	5.42
Ehretaceae	<i>Ehretia laevis</i>	7.26	5.84
Bignoniaceae	<i>Millingtonia hortensis</i>	7.20	4.63
Euphorbiaceae	<i>Bridelia squamosa</i>	7.15	4.76
Rubiaceae	<i>Xeromphis uliginosa</i>	6.75	4.86
Combretaceae	<i>Terminalia bellerica</i>	6.64	5.84
Casuarinaceae	<i>Casuarina equisetifolia</i>	6.24	4.46
Lythraceae	<i>Lawsonia inermis</i>	5.24	4.26
Combretaceae	<i>Terminalia catappa</i>	5.12	5.37
Palmae	<i>Phoenix sylvestris</i>	4.36	5.56
Myrtaceae	<i>Melaleuca leucadendron</i>	3.93	4.88
Maraceae	<i>Ficus racemosa</i>	3.91	4.20
Moraceae	<i>Streblus asper</i>	3.68	5.96
Myrtaceae	<i>Eucalyptus globulus</i>	2.83	4.50
Palmae	<i>Borassus flabellifer</i>	1.03	4.83
Category IIID (less than 10% protein N extracted from the leaf and LPC containing less than 4% nitrogen of dry matter)			
Ehretiaceae	<i>Cordia dichotoma</i>	5.74	3.68
Rubiaceae	<i>Gardenia latifolia</i>	5.06	3.36
Lythraceae	<i>Lagerstroemia speciosa</i>	2.67	3.73
Palmae	<i>Cocos nucifera</i>	2.08	2.84
Combretaceae	<i>Terminalia arjuna</i>	1.95	3.95
Moraceae	<i>Morus indica</i>	1.79	1.52

the leaves during harvest, nitrogen level of the substrate, procedures involved in separating the protein from leaves and the dehydration of leaf samples (PIRIE 1955, ARKCOLL 1971). So, in this survey the pre-flowering stage was selected and the medium mature leaves were picked randomly to avoid the age factor. Soft-textured, sappy leaves are most suitable as protein sources. In this investigation water was used as the medium for extraction of leaf protein. Twice of the weight water was added and homogenized in a waring blender. It is known that in aqueous solution the nutritive cytoplasmic fraction is easily dissolved. However, the chloroplast fraction to be dealt with ruminants whose digestive system is better suited to such material (WOODHAM 1969). In the extraction process the homogenate was coagulated and centrifuged for the separation of the cytoplasmic and chloroplast fraction.

Proteins are in a state of continual flux in plants and the net amount at any one time depends on the balance between synthesis and degradation. The highest rate of protein synthesis and the minimum degradation may be expected at the pre-flowering stage of the plant (PIRIE 1955).

Varying degrees of difficulty have been encountered during the homogenization and disintegration of tissues of different plant species. In the present investigation, the leaf tissues of the families Combretaceae, Lythraceae, Rubiaceae, Sapotaceae, Bignoniaceae, Euphorbiaceae, Verbenaceae, and Apocynaceae were found to be fairly soft and easy to disrupt whereas those of the families Moraceae and Palmae etc. contained comparatively much fibre and presented some difficulty during mincing. The type of machinery and the structure of the tissue are not, however, the only factors that can influence the extractability of leaf protein concentrates. Phenols and their oxidative products were also reported to interfere with the extraction rate (COHEN et al. 1956; LOOMISH and BATTAILE 1966). But in the present investigation this was not noticed. However, interference of the mucilaginous substance directly affecting the extraction rate of protein was taken in consideration.

The extractability of leaf protein and the LPC yield varied considerably among the species tested as shown in Table 2. The maximum extractability of LPC was recorded in the families Sapotaceae and Lecythidaceae (more than 18% LPC extraction). Some other species, such as *Ardisia solanacea* and *Trewia polycarpa* etc., had satisfactory levels of extraction. This extraction rate is also directly influenced by leaf area and leaf arrangement due to capture of more effective light for photosynthesis, so the highest nitrate reduction should be noticed for these leaves. The lowest values of LPC yield were found for the families Combretaceae, Euphorbiaceae, Moraceae and Palmae. These families in general show most fibrous species which influence the yield of protein extraction. However, leguminous plants would be better protein producers economically owing to their ability to assimilate molecular, atmospheric nitrogen in the form of nitrate to nitrite.

Several workers (BYERS 1961; VALLI DEVI et al. 1965; GHOSH 1967) worked on some tree species and concluded that these species are rich in fibrous matter and dry matter but total nitrogen and protein nitrogen were also higher in comparison with some cereal leaf protein concentrates. It was found that total nitrogen, protein nitrogen, protein and ash contents were higher in LPC in comparison with the leaf samples of the same species. This is due to a higher concentration of these components in LPC. However, the values of extractability of LPC and percentage extractabilities of total nitrogen and protein nitrogen of LPC were calculated values (Tables 2 and 3).

The amount of LPC that can be obtained from leaf samples depends considerably on the pH of leaf extracts (SINGH 1964, PIRIE 1971). Thus the precipitation was adjusted by adding 1 N-HCl at pH 4.5. This is probably close to the isoelectric point at which protein (charged particles) breaks its weak bonding and comes in the form of ions and precipitation occurs. Protein content and its extractability vary in leaf samples of different species (VALLI DEVI et al. 1965).

Coagulation is one of the important steps in extractions of protein from leaves. By heat coagulation the leaf juice can be separated into two fractions at different temperatures. At 60 °C first the cytoplasmic fraction was separated followed at 80 °C by the chloroplast fraction.

Ricinus communis (castor oil tree) did not yield much protein but it was not known to what extent the extraction rate was affected by the proteolytic enzyme papain present in the leaves. Some of the leaves showed a higher percentage of protein extraction while their total nitrogen content was found lower. For these factors the surveyed plants were categorized into three main, and four sub-groups on the basis of the protein nitrogen extracted from the leaf and LPC containing nitrogen on the basis of dry matter. The plants with high LPC extractability and protein nitrogen dry matter were found suitable for further studies (VALLI DEVI et al. 1965; BYERS 1961).

ALEXANDER et al. (1970) supported the view that the protein production per unit of leaf area is directly influenced by the application of fertilizer, rapid growth of plants, suitable leaf arrangement, large leaf area and per cent extractability of leaf protein concentrate.

ACKNOWLEDGEMENTS

The author is thankful to the Head of the Botany Department, Gorakhpur University, Gorakhpur, India for providing laboratory facilities.

REFERENCES

- A.O.A.C. (1960): Methods of analysis. *Assoc. Offic. Agric. Chem.* Washington DC.
Arkcoll, D. B. (1971): *Leaf Protein. Its Agronomy, Preparation, Quality and Use.* IBP Handbook No. 20, ed. N. W. Pirie (Blackwell Scientific Publications, Oxford), p. 29.

- Byers, M. (1961): The extraction of protein from the leaves of some plants growing in Ghana. *J. Sci. Fd. Agric.* **12**: 20.
- Byers, M. (1971): Amino acid composition and *in vitro* digestibility of some protein fractions from three species of leaves of various ages. *J. Sci. Fd. Agric.* **22**: 242.
- Cohen, M., Ginoza, W., Dorner, R. W., Hudson, W. R., Wildman, S. G. (1956): Solubility and color characteristics of leaf proteins prepared in air or nitrogen. *Science*, N. Y. **124**: 1081.
- Doneen, L. D. (1932): A micro method for nitrogen in plant material. *Pl. Physiol.* **7**: 717.
- Ghosh, J. J. (1967): Leaf protein concentrates: Problems and prospects in the control of protein malnutrition. *Trans. Bose Res. Inst.* **30**: 215.
- Lexander, K., Carlsson, R., Schalen, V., Simonsson, A., Lundborg, T. (1970): Quantities and qualities of leaf protein concentrates from wild sps., Crop sps. grown under controlled conditions. *Ann. Appl. Biol.* **66**: 193.
- Loomis, W. D., Battaile, J. (1966): Plant phenolic compounds and the isolation of plant enzymes. *Phytochemistry* **5**: 423.
- Morrison, J. E., Pirie, N. W. (1961): The large scale production of protein from leaf extract. *J. Sci. Fd. Agric.* **12**: 1.
- Pirie, N. W. (1955): Protein in *Modern Methods of Plant Analysis*, ed. K. Peach and M. V. Tracey, Springer Verlag Berlin.
- Pirie, N. W. (1957): Leaf protein as human food. *Fd. Mf.* **32**: 416.
- Pirie, N. W. (1971): *Leaf Protein. Its Agronomy, Preparation, Quality and Use*. IBP Handbook No. 20. Blackwell Scientific Publications, Oxford.
- Sharma, D. N., Srivastava, A. K., Srivastava, R. P. (1975): Leaf protein concentrates in three common weeds. *Geobios* **2**: 128.
- Singh, N. (1964): Leaf protein extraction from some plants of Northern India. *J. Fd. Sci. Tech.* **1**: 37.
- Singh, N. (1974): Prospects for leaf protein research and development. *J. Sci. Ind. Res.* **33**: 51.
- Snell, F. D., Snell, C. T. (1953): *Colorimetric Methods of Analysis*. Van Nostrand, N. Y., p. 215.
- Valli Devi, A., Rao, N. A. M., Vijayaraghwan, P. K. (1965): Isolation and composition of leaf protein from certain species of Indian Flora. *J. Sc. Fd. Agric.* **16**: 116.
- Woodham, A. A. (1969): Separation of protein concentrates from green leaves and seeds. *Chem. and Ind.* **1990**: 60.

THE EFFECT OF INCREASING NITROGEN DOSES UPON DRY MATTER PRODUCTION, TRANSPIRATION AND WATER UTILIZATION OF MAIZE PLANTS

S. SZLOVÁK

RESEARCH INSTITUTE FOR IRRIGATION, SZARVAS, HUNGARY

(Received: 1 June 1982)

Pot experiments were conducted in a growth-house to determine the effect of nitrogen doses upon dry matter production, transpiration and water utilization of maize (*Zea mays* L.).

On both soil moisture levels used in the experiments, the high nitrogen doses decreased the dry matter weight of plant parts and the transpiration. Transpiration intensity calculated per unit leaf area decreased at nitrogen doses higher than in the N_{15} PK-treatment. The decreasing transpiration resulted from the smaller plant surface and quality differences in leaves. With the exception of plants developed at the lowest nitrogen dose the water utilization calculated per unit grain weight was more favourable in all nitrogen treatments at optimum soil moisture than at low water supply.

Introduction

Nitrogen plays a very important role in building the proteins and nucleic acids of the living organisms. The proteins are important structural elements of the living cells, of the vital compounds regulating them, the enzyme catalysts, of the various cell membranes and of the different carriers operating in the ion uptake mechanism. Nucleic acids carry the genetic characteristics on to the progeny. The important role nitrogen plays in the plant life makes comprehensive, detailed studies of nitrogen effect upon plant growth and water economy of plants indispensable.

According to our earlier experimental data (SZLOVÁK 1974a, 1974b, 1979a) on alluvial-meadow soil, among the three main macrolelements used in agriculture, nitrogen affected the yield and transpiration rate of maize to the greatest extent (Figs 1 and 2). Figure 1 shows that during the growth season there is an increasing difference in dry plant weight of the nitrogen-treated plants and those receiving no nitrogen fertilizer. At shooting development stage (plant height about 1 m; 30th June) the effect of nitrogen deficiency was only slight yet because the nitrogen content of the soil could to a certain extent supply the developing plant with nitrogen. At tasseling (22nd July) there was a definite difference in the dry weight of nitrogen-treated plants and those receiving no nitrogen fertilizers. This difference increased during the growth season and at the waxy and ripening development stage it was more than double. Figure 2 shows that there is a smaller difference in the transpiration than in dry weight of the nitrogen-treated plants and those receiving no nitrogen. This means that the utilization of water was better at nitrogen treated plants than at plants receiving no nitrogen fertilizers. Figure 3 shows that in the average of treatments containing no nitrogen the plants had a higher transpiration coefficient than the plants in the nitrogen containing treatments. The better water utilization was due to a higher rate of dry matter production in the nitrogen containing treatments. The higher dry matter production was coupled with a smaller rate of transpiration increase. The experimental results clearly indicate the yield increasing- and better water utilization effect of nitrogen.

To see whether the increased nitrogen doses also increase the dry matter yield, the transpiration and the water utilization, culture pot experiment was carried out using six nitrogen doses on optimum (70% of maximum waterholding capacity of soil) and low (50% of maximum waterholding capacity of soil) soil moisture levels.

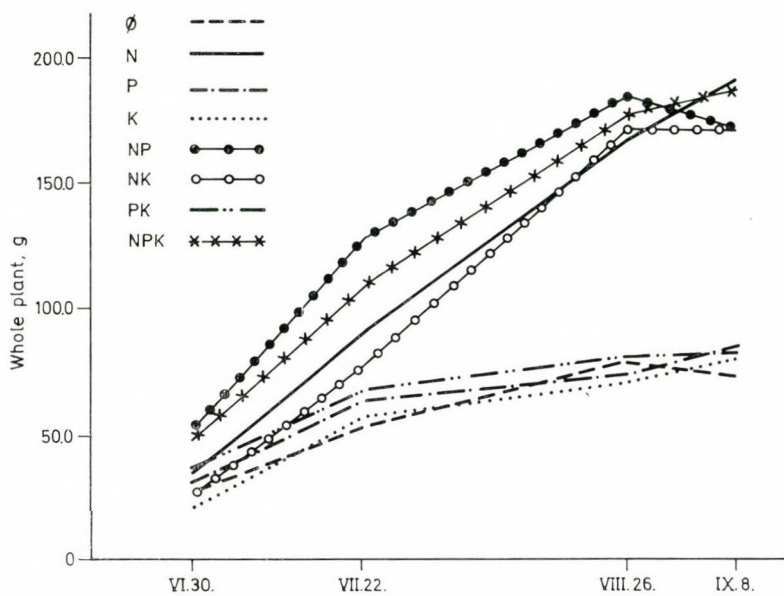


Fig. 1. Effect of nutrients upon the dry yield of maize

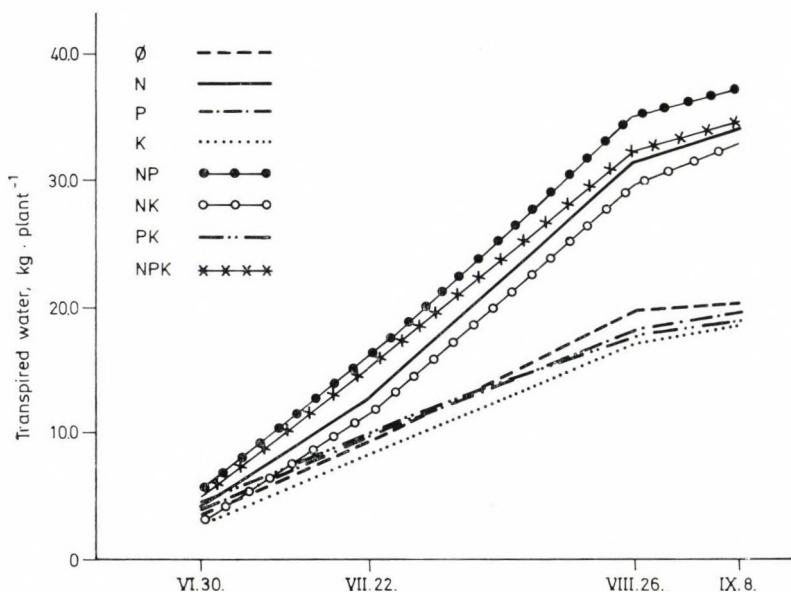


Fig. 2. Effect of nutrients upon the transpiration of maize

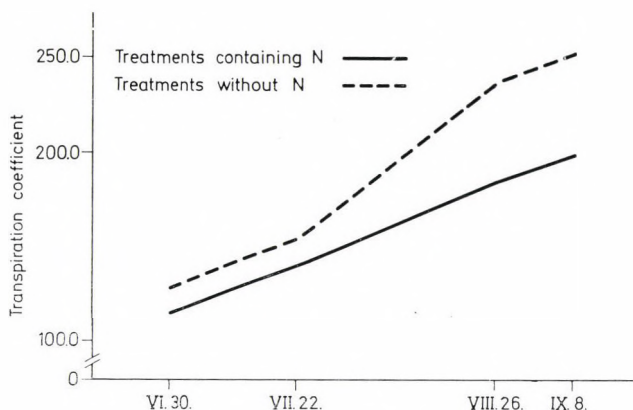


Fig. 3. Effect of nitrogen upon the transpiration coefficient of maize

Material and method

In 1977 on the 5th of May and in 1978 on the 4th of May maize seeds were planted in pots in a growth-house. The plants were exposed to environmental factors nearly identical with those in the field since the culture pots containing the plants were placed on carts running on a track and moved every morning into a space enclosed by a wire net. For the night and when it rained the carts were pushed under a glass roof.

In the 20 × 25 cm white enamel painted pots for six kg absolute dry soil, air dry alluvial-meadow surface soil (Szarvas-Bikazug) was placed. The maximum water-holding capacity of 49.90% was obtained (expressed in weight % of absolute dry soil). The soil on which the Mv-580 hybrid maize plants developed was filled with water to 50 and 70% of its maximum water-holding capacity at daily waterings.

The active ingredients of fertilizers per pot in the fertilized treatments were as follows: N: 2.4 g (ammonium nitrate), P_2O_5 : 1.2 g (superphosphate), K_2O : 1.2 g (potash, KCl). The lowest nitrogen dose was 1.2 g and the highest 7.2 g per pot. The increment of the nitrogen doses was 1.2 g. All nitrogen treatments contained the same amount of phosphorus and potash.

Five seeds were sown per pot. After emergence the plants were thinned to one in each pot. There were ten replicates for all treatments in both years. For transpiration measurements the pot soil was covered with PVC film. Thus the water loss from the pot was due only to the transpiration by plants. The amount of transpired water was restored by daily waterings. The fresh plant weight increase during the growth season was taken into account at waterings. The fresh weight increase of plants was determined by periodic harvesting during the growth season. The plants were harvested on 15th September 1977 and on 25th of September in 1978. At harvest the roots were washed out of the pot soil. After separation, the plant parts were dried at an oven temperature of 60 °C. The drying continued until there was no more change in the subsequent weight measurements.

Some other soil characteristics were as follows:

pH	H ₂ O	6.73
	KCl	5.69
Total salt, %		0.06
Humus, %		2.06
Total N, %		0.14
P ₂ O ₅	AL-P	mg/100 g
	method	6.47
K ₂ O	AL-K	soil
		18.20

Results and discussion

With the exception of leaf-blade and grain produced at low soil moisture, the dry weight of plant parts and also the dry yield of the whole plants at both soil moisture levels gave the highest value in response to $N_{1.0}$ PK treatment. There was no significant difference between the above-mentioned two plant parts (leaf-blade and grain) in their response to $N_{0.5}$ PK and $N_{1.0}$ PK treatments at low soil moisture. Husks did not react to the nitrogen doses like the other plant parts.

Figures 4 and 5 show the effect of nitrogen doses upon the maize development at two soil moisture levels. The effect of increasing nitrogen doses upon the dry weight of plant parts, transpiration and water utilization can be seen in Table 1.

As shown in Table 1 at both soil moisture levels, after having reached the highest root weight (in the $N_{1.0}$ PK treatment), the increasing nitrogen doses decreased the root weight. Although at both soil moisture levels the highest root weight was obtained in response to $N_{1.0}$ PK treatment the highest root weight increase per unit weight of applied nitrogen was observed at the nitrogen dose of $N_{0.5}$. At low soil moisture this increase related to the control was 203.47% and at optimum soil moisture 252.90%. By doubling the nitrogen dose ($N_{1.0}$ PK) the root weight increase was only 218.93 and 268.30% related to the control. Thus a 100% nitrogen increase resulted only in a 15.46% and 15.40% additional root weight increase, respectively.

The root weights of plants under optimum water supply were higher than those under low soil moisture conditions, with the exception of those in the PK treatment. The greatest difference occurred at the highest nitrogen dose ($N_{3.0}$ PK) where the root weight of the plants at optimum water supply was three times that of plants at low soil moisture level.

Similarly to the root weight, the weight of stalk, after having reached the maximum, decreased as a result of increasing nitrogen doses at both soil moisture levels. In the stalk the



Fig. 4. Effect of nitrogen doses upon maize development at low soil moisture level



Fig. 5. Effect of nitrogen doses upon maize development at optimum water supply

weight increase at $N_{0.5}$ PK treatment related to the control was smaller than in the roots. At low soil moisture this weight increase was 131.90% and at optimum water supply 156.89%. Thus there was a differential weight increase reaction of roots and stalks to the nitrogen at both soil moisture levels. The applied nitrogen increased the root weight to a greater extent than the weight of stalk. The difference in stalk weight in response to $N_{0.5}$ PK and $N_{1.0}$ PK treatment like in the case of roots was relatively small (11.60% at low — and 9.92% at optimum soil moisture). As with the roots, the greatest difference between the stalk weight at the two soil moistures occurred at $N_{3.0}$ PK treatment, but it was considerably lower than in the case of roots. Stalk weight of plants grown at optimum soil moisture in this treatment was slightly more than double of those grown at low water supply.

Like the above-discussed plant parts a lower weight in leaf-blade resulted from the nitrogen and water deficiency, which limited the life processes and also lead to the earlier death of leaf-blades. The death resulting from nitrogen deficiency is the function of the nitrogen content of the plant. At low nitrogen doses the nitrogen concentration of the plant was not sufficient for normal life processes even at optimum water supply. Leaf-blade death was influenced also by the ratio of transpiration and water uptake. As transpiration exceeded the water uptake at first the lower leaves became dehydrated. This dehydration caused an irreversible damage in leaf-blades. The death of leaves could be observed also in plants well supplied with nitrogen and water but this process was due to the senescence of plants and started only after anthesis. Mainly the leaves determine the dry matter production and their size greatly depends upon the nutrient supply. The proper nitrogen supply usually increases the leaf area which results from an increased number or increased size of leaves or from both. The leaf area is influenced by the number and the size of cells. Nitrogen — depending upon the dose — may also increase the longevity of leaves.

Contrary to the roots and stalks the maximum dry weight of leaf blades was obtained at different treatments at the two soil moisture levels. While at low soil moisture the $N_{0.5}$ PK,

Table 1
The effect of increasing nitrogen doses upon the dry matter weight

Plant parts	Treatment									
	Root g		Stalk g		Leaf blade g		Husks g		Cob g	
	50*	70	50	70	50	70	50	70	50	70
Control	6.92	8.96	23.45	32.57	10.00	12.31				
PK	9.06	9.04	26.85	34.92	11.77	13.28				
N _{0.5} PK	14.08	22.66	30.93	51.10	17.14	23.29	7.16	12.71	10.22	17.41
N _{1.0} PK	15.15	24.04	33.65	54.33	15.82	26.84	7.09	14.94	11.66	23.23
N _{1.5} PK	13.04	23.57	30.58	51.82	14.90	25.27	6.33	14.01	9.37	21.65
N _{2.0} PK	10.38	23.61	29.18	51.89	14.44	25.08	7.41	17.48	7.46	21.12
N _{2.5} PK	8.99	18.96	27.03	41.49	13.31	22.32	7.56	13.73	7.18	19.21
N _{3.0} PK	5.73	17.49	19.21	41.41	10.37	20.64	4.72	14.29	4.09	15.82
LSD 0.1%	4.45		8.49		2.53		4.01		2.48	
1.0%	3.45		6.60		1.96		3.10		1.92	
5.0%	2.61		4.99		1.48		2.35		1.45	

<i>Significant difference between the same fertilizer</i>										
LSD 0.1%	4.38		8.26		2.66		3.91		2.55	
1.0%	3.41		6.42		2.06		3.02		1.97	
5.0%	2.57		4.85		1.56		2.29		1.49	

* Soil moisture in per cent of its maximum water-holding capacity

at optimum soil moisture the N_{1.0} PK treated plants had the highest dry leaf-blade weight. After reaching the maximum the increasing nitrogen doses decreased the leaf-blade weight. The greatest difference between the leaf-blade weight of plants at the two soil moisture levels was observed at the N_{1.0} PK treatment.

It can be seen in Table 2 that at both soil moistures in plants undergoing nitrogen-free treatment (PK) and in the control plants the ratio of stalk to leaf blade is higher than in plants subjected to nitrogen treatment.

The most important plant part, the grain, developed only in plants given nitrogen containing treatment, thus the cob and the husks were not weighed separately but together with the stalk in the controls and in the PK-treated plants. The weight of the husks was not influenced by the different nitrogen doses as it was observed for other plant parts. At the same time, the optimum water supply resulted in a significantly higher husk weight.

After having reached the highest weight, the grain and the cob weight decreased as the nitrogen increased.

The grain yield of maize depends upon the synthetic activity of the leaf blade. As can be seen in Table 3, the effect of various nitrogen doses upon the grain weight calculated per unit of leaf-blade weight was different. At both soil moisture levels the highest grain weight per 1 g of leaf blade was obtained at N_{1.0} PK treatment (2.85 g at low moisture and 4.03 g

of plant parts, transpiration and water utilization of maize plants

Plant parts									
Grain g		Whole plant g		Transpiration kg		Transpiration coefficient calculated for the whole plant		Transpiration coefficient calculated for grain	
50	70	50	70	50	70	50	70	50	70
		40.35	56.83	7.66	11.31	191.52	201.39		
		47.67	59.06	7.71	10.63	162.00	180.85		
45.26	70.12	126.26	196.96	16.55	29.07	132.39	147.92	369.14	418.78
44.71	107.87	128.00	253.00	14.32	32.78	112.29	129.68	323.97	306.94
37.59	94.85	112.43	231.20	13.69	33.18	121.72	143.62	368.80	353.87
28.99	82.03	97.60	224.69	12.40	29.49	127.59	131.39	436.68	362.10
20.40	69.24	84.94	189.75	10.54	23.81	124.95	126.00	558.08	349.32
14.46	55.45	58.84	167.10	6.69	21.59	114.21	129.79	468.72	397.85
12.78		17.19		1.95		20.52		112.44	
9.89		13.36		1.52		15.96		86.97	
7.48		10.10		1.15		12.12		65.81	
<i>treatments of the two soil moisture groups</i>									
11.87		16.41		1.92		19.71		108.60	
9.18		12.76		1.49		15.33		84.00	
6.95		9.64		1.13		11.64		63.56	

at optimum soil moisture). The different values obtained at the two soil moisture levels indicate that besides the nitrogen doses, the water supply also significantly influenced the effect of leaf blades upon grain yield. There was a significant difference during all nitrogen treatments between the two soil moisture levels as regards the grain weight yield per unit of leaf-blade weight. The greatest difference (1.57 g) was observed in the $N_{2.5}$ PK-treatment.

The dry weight of whole plants was also affected by the nitrogen doses and the two soil moisture levels, i.e. nitrogen deficiency as well as its excess and also low soil moisture reduced dry matter production.

There was a great difference in the ratio of the whole plant weight of control and $N_{3.0}$ PK-treated plants grown at the two soil moisture levels. While at low soil moisture this ratio was 68.58%, at optimum soil moisture it decreased to 34.01%. These differences were evident shortly before tasseling (Figs 4 and 5).

Nitrogen played a very important role in the dry matter production of the whole plants. Even at deficient water supply the weight of the $N_{1.0}$ PK-treated plants was 3.17 times higher than that of nitrogen-free control plants. The weight of $N_{1.0}$ PK-treated plants was also 2.69 times higher than that of the PK-treated ones.

In nitrogen deficient plants (control and PK-treatment) at both soil moistures the ratio of root and whole plant weight was significantly ($P < 0.001$) higher than in the nitrogen

Table 2

Stalk-leaf blade ratio of maize plants in response to nitrogen-free and nitrogen containing treatments

Treatment	Stalk, g		Leaf blade, g		Stalk-leaf blade ratio	
	50*	70	50	70	50	70
Control	23.45	32.57	10.00	12.31	2.343	2.641
PK	26.85	34.92	11.77	13.28	2.281	2.633
N _{1.0} PK	33.65	54.33	15.82	26.84	2.156	2.030
LSD 0.1%	7.43		2.12		0.427	
1.0%	5.63		1.60		0.324	
5.0%	4.20		1.20		0.242	

Significant difference between the same fertilizer treatments of the two soil moisture groups

LSD 0.1%	7.47	1.90	0.445
1.0%	5.66	1.44	0.337
5.0%	4.22	1.08	0.252

* Soil moisture in per cent of its maximum water-holding capacity

treated plants (Table 4). At low soil moisture the root and whole plant weight ratio was higher than at optimum water supply. The plants reacted to the limited nitrogen and water supply in the soil with a relatively more active root development in order to utilize better the available scarce nitrogen and water.

The obtained experimental data indicate that even at low soil moisture the applied nitrogen may increase the yield of the whole plants significantly (Table 1). At low soil moisture the yield of the N_{1.0}PK-treated plants was 2.25 times and 2.17 times higher, respectively, than the yield of controls and PK-treated plants at optimum water supply. That is, the yield-increasing effect of nitrogen at low soil moisture was much higher than the effect of water at the nitrogen-free control and PK-treated plants at optimum soil moisture.

In relation to the yield-increasing effect of nitrogen GARWOOD and WILLIAMS (1967) observed that under field conditions if the growth of grasses stopped during drought and nitrogen was injected in the deeper soil layers the grasses again began to grow without irrigation. The probable explanation is that the plants could not utilize the nitrogen in the upper dry soil layers. The deeper, wet soil layers ensured the utilization of the injected nitrogen. In our pot experiment even under low soil moisture conditions the nitrogen significantly increased the yield.

The nitrogen doses and the different water supply also influenced the weight ratio of grain and whole plant. As it can be seen in Table 5 the weight ratio of grain and whole plant after reaching the highest value decreases as the nitrogen doses increase. The highest grain and whole plant ratio, 0.428 was obtained at optimum water supply with $N_{1.0}$ PK-treatment. The grain and whole plant ratio was more favourable at optimum than at low water supply. A more favourable grain ratio was obtained if the root weight was omitted in our calculations. Thus the ratio of grain and above-ground plant parts at optimum soil moisture under $N_{1.0}$ PK treatment rose to 0.471

The differential nitrogen and water supply besides the plant weight significantly influenced also the transpiration. With the exception of the highest nitrogen dose treatment at low soil moisture, the plants in the nitrogen-containing treatments transpired more than in the nitrogen-free treatments. Similar results were obtained also by K. DEBRECZENI (1965), B. DEBRECZENI (1970) and SZLOVÁK (1974a, 1974b, 1979a and 1979b).

At low soil moisture the maximum transpiration of plants was observed at a lower nitrogen dose ($N_{0.5}$ PK) than at optimum water supply ($N_{1.5}$ PK).

Table 3

Effect of nitrogen doses upon leaf-blade weight, grain yield and grain yield per unit of leaf-blade weight at two soil moisture levels

Treatment	Leaf-blade weight g		Grain-weight g		Grain yield calculated for 1 g leaf-blade weight, g		The ratio of plants grown at optimum and low soil moisture
	50*	70	50	70	50	70	
N _{0.5} PK	17.14	23.29	45.26	70.12	2.64	3.03	1.15
N _{1.0} PK	15.87	26.84	44.71	107.87	2.85	4.03	1.41
N _{1.5} PK	14.90	25.27	37.58	94.85	2.53	3.79	1.50
N _{2.0} PK	14.44	25.08	28.99	82.03	2.02	3.28	1.62
N _{2.5} PK	13.31	22.32	20.40	69.24	1.53	3.10	2.03
N _{3.0} PK	10.37	20.64	14.46	55.45	1.43	2.71	1.90
LSD 0.1%	2.96		12.78		0.61		
1.0%	2.29		9.89		0.47		
5.0%	1.73		7.48		0.36		
<i>Significant difference between the same fertilizer treatments of the two soil moisture groups</i>							
LSD 0.1%	2.86		11.87		0.58		
1.0%	2.21		9.18		0.45		
5.0%	1.67		6.95		0.34		

* Soil moisture in per cent of its maximum water-holding capacity

Table 4

The weight ratio of roots and whole plants in the nitrogen-free and nitrogen containing treatments

Treatment	Root g		Whole plant g		Root-whole plant ratio	
	50*	70	50	70	50	70
Control	6.90	8.96	40.35	56.83	0.170	0.160
PK	9.06	9.04	47.58	59.06	0.191	0.153
N _{1,0} PK	15.15	24.04	128.00	253.00	0.119	0.095
LSD 0.1%	4.31		12.57		0.039	
1.0%	3.26		9.52		0.030	
5.0%	2.44		7.11		0.022	

Significant difference between the same fertilizer treatments of the two soil moisture groups

LSD 0.1%	3.98	11.49	0.036
1.0%	3.02	8.70	0.027
5.0%	2.25	6.50	0.020

* Soil moisture in per cent of its maximum water-holding capacity

After reaching the highest transpiration value the increasing nitrogen doses decreased the transpiration. During the whole growth season the lowest transpiration was obtained at the highest nitrogen dose (N_{3,0}PK) in the case of low soil moisture and in the PK-treatment in that of optimum water supply. The greatest difference in the transpiration of plants grown on the two soil moisture levels was observed at the highest nitrogen dose. At this kind of treatment the plants grown at optimum soil water level transpired more than three times as much as the plants at low water supply. The transpiration decreasing effect of increasing nitrogen doses is due partly to the smaller transpiring area. The leaf-blade weight ratio of N_{3,0}PK-treated plants related to the leaf-blade weight of the N_{1,5}PK-treated ones (highest transpiration) decreased to 81.68% at optimum water supply. At low soil moisture this ratio of N_{3,0}PK- and N_{0,5}PK (highest transpiration)-treated plants was only 60.50%. At low soil moisture the maximum transpiration took place in response to N_{0,5}PK treatment. Besides the decreasing leaf-blade weight and leaf-blade area, the quality of the leaf blades were also different under the various nitrogen treatments. Nitrogen doses above N_{1,5}PK decreased the transpiration calculated per unit of leaf area at both soil moistures levels (Table 6). The transpiration calculated per unit of leaf area at optimum water supply was

significantly higher ($P < 0.001$) than in plants grown at low soil moisture in each treatment group.

A decrease in transpiration could be observed not only in plants with increasing nitrogen doses, but also in those which did not receive any nitrogen (control and PK treatment). At low soil moisture the PK-treated and control plants transpired only 46.59% and 46.28%, respectively, of those subjected to $N_{0.5}$ PK treatment. At optimum soil moisture this ratio was 36.57% and 38.91%. The low transpiration values of nitrogen deficient plants, like at high nitrogen doses, resulted from smaller plant surface and qualitative changes in the plants.

One of the main reasons of decreased transpiration at high nitrogen doses is very likely the limited water uptake. In our experiments at both soil moisture levels the increased nitrogen doses also increased the total salt content of the soil. Generally the water uptake by plants is more dependent upon the salt or nutrient concentration than on its composition. The water uptake of maize roots was the same in the experiment of HAWARD and SPURR (1944) using the same osmotic potentials of sucrose, mannitol, sodium sulphate

Table 5
*Grain-whole plant (including the roots) ratio as a function
of nitrogen treatments*

Treatment	Grain g		Whole plant g		Grain-whole plant ratio	
	50*	70	50	70	50	70
$N_{0.5}$ PK	45.26	70.12	126.26	196.96	0.349	0.356
$N_{1.0}$ PK	44.71	107.87	128.00	253.00	0.350	0.428
$N_{1.5}$ PK	37.59	94.85	112.43	231.20	0.335	0.410
$N_{2.0}$ PK	28.99	82.03	97.60	224.69	0.301	0.365
$N_{2.5}$ PK	20.40	69.24	84.94	189.75	0.239	0.365
$N_{3.0}$ PK	14.46	55.45	58.84	167.10	0.245	0.331
LSD 0.1%	12.78		19.41		0.068	
1.0%	9.89		15.02		0.053	
5.0%	7.48		11.36		0.040	

*Significant difference between the same fertilizer treatments
of the two soil moisture groups*

LSD 0.1%	11.87	18.73	0.065
1.0%	9.18	14.49	0.050
5.0%	6.95	10.96	0.038

* Soil moisture in per cent of its maximum water-holding capacity

Table 6*Maize transpiration calculated for unit of dry weight of leaf blade*

Treatment	Leaf blade g		Transpiration kg		Transpiration per unit of leaf-blade weight	
	50*	70	50	70	50	70
Control	10.00	12.31	7.66	11.31	769.86	917.63
PK	11.77	13.28	7.71	10.63	655.23	801.83
N _{0.5} PK	17.14	23.29	16.55	29.07	967.11	1261.12
N _{1.0} PK	15.82	26.84	14.32	32.78	913.48	1223.68
N _{1.5} PK	14.90	25.27	13.69	33.18	917.93	1323.90
N _{2.0} PK	14.44	25.08	12.40	29.49	861.64	1176.96
N _{2.5} PK	13.31	22.32	10.54	23.81	800.48	1069.14
N _{3.0} PK	10.37	20.64	6.69	21.59	672.10	1060.87
LSD 0.1%	7.11		1.95		145.01	
1.0%	5.53		1.52		112.74	
5.0%	4.18		1.15		85.20	

<i>Significant difference between the same fertilizer treatments of the two soil moisture groups</i>						
LSD 0.1%	6.77		1.92		142.48	
1.0%	5.27		1.49		110.77	
5.0%	3.34		1.13		83.71	

* Soil moisture in per cent of its maximum water-holding capacity

and sodium chloride. It is very likely that in our experiments the high nitrogen doses increased the nutrient concentration to a such degree which already limited the water uptake by the plants. As a result of limited water uptake, water deficit developed in the plants. In turn, this water deficit decreased the opening of stomata. LÖSCH (1979) in his studies on epidermis tissues of *Polypodium vulgare* concluded that a small water deficit influenced the stomata openings only slightly. As the rate of water potential under the epidermis cells decreased the openings of stomata became smaller and smaller. If the water potential sank below -20 bars open stomata were observed only under favourable environmental conditions.

In our experiments the almost closed and closed stomata decreased not only the transpiration, but also limited the diffusion of CO₂ through the stomata which resulted in a reduced dry matter production depending upon the nitrogen doses and water supply. LOF (1976) examined the effect of nitrogen deficiency upon photosynthesis and transpiration in two grass species (*Phalaris* and *Hordeum*) in a climate room. These species were kept for eleven days in

the nitrogen deficient nutrient solution. The transpiration decrease of both species was about the same, and much lower than that of the photosynthesis. Since transpiration decreased to a smaller extent than photosynthesis, the water utilization of nitrogen deficient plants was more unfavourable.

Our maize plants undergoing nitrogen containing treatments utilized the water significantly ($P < 0.001$) more efficiently during the growth season at both soil moisture levels than the nitrogen deficient ones (control and PK-treated). GOUDRIAAN and KEULEN (1979) postulated that "deterioration of water use efficiency for whole plants or crops under conditions of N shortage may . . . have to be attributed to differences in the distribution pattern of the assimilates, notably a larger share for the underground plant parts". Our experimental results do not support this postulation, because if water utilization is calculated for the dry matter of the whole plant (including the "underground part", the roots) the water use efficiency is more favourable in plants subjected to nitrogen treatments than in nitrogen stressed plants (control and PK treatment).

Under optimum or near-optimum conditions the water utilization of plants with higher dry-matter weight is usually better than of those with low dry-matter weight. Nevertheless, this is not always true under unfavourable conditions. In our experiments at low soil moisture, unfavourable for plant growth, the transpiration ratio, calculated for the whole plant was lower than at optimum water supply. A different water utilization value was obtained if the transpiration ratio was calculated for the most important plant part, the grain. In this case with the exception of the lowest nitrogen dose the water utilization calculated per unit grain weight was more favourable for plants developed at optimum soil moisture. At both soil moisture levels the most favourable water utilization calculated for unit of grain weight was obtained in the $N_{1.0}$ PK treatment.

REFERENCES

- Debreczeni, K. (1965): Víz- és tápanyagellátás hatása a kukorica transzspirációjára és tápanyagfelvételére (The effect of water- and nutrient supply upon the transpiration and nutrient uptake by maize plants). *Öntözéses Gazdálkodás* **2**: 129–148.
- Debreczeni, B. (1970): A tápanyag- és vízellátás főbb összefüggéseinek agrokémiai vonatkozásai (The main correlations between nutrient and water supply in relation to agrochemistry). Thesis.
- Garwood, E. A., Williams, T. E. (1967): Growth, water use and nutrient uptake from the subsoil by grass swards. *J. Agric. Sci. Camb.* **69**: 125–130.
- Goudriaan, J., Keulen, H. van (1979): The direct and indirect effect of nitrogen shortage on photosynthesis and transpiration in maize and sunflower. *Neth. J. Agric. Sci.* **27**: 227–234.
- Haward, H. E., Spurr, W. B. (1944): Effect of osmotic concentration of inorganic and organic substrates on entry of water into corn roots. *Bot. Gaz.* **106**: 131–139.
- Lof, H. (1976): Water use efficiency and competition between arid zone annuals, especially the grasses *Phalaris minor* and *Hordeum murinum*. *Agr. Res. Rep.* 853. Pudoc. Wageningen.

- Lösch, R. (1979): Responses of stomata to environmental factors. Experiments with isolated epidermal strips of *Polypodium vulgare*, II. Leaf bulk potential, Air Humidity and Temperature. *Oecologia (Berl.)* **39**: 229–238.
- Sváb, J. (1973): *Biometriai módszerek a kutatásban* (Biometrical Methods in Research). Second edition. Mezőgazdasági Könyvkiadó, Budapest.
- Szlovák, S. (1974a): A kukorica levéllemezének összes nitrogéntartalma és az egész növény transzspirációja közötti kapcsolat vizsgálata (Relationship between total nitrogen content of the maize leaf blade and amount of water transpired by the whole plant) *Növénytermelés* **23**: 34–54.
- Szlovák, S. (1974b): A kukorica egységnyi levélfelületére számított transzspiráció intenzitás különbségek különböző tápanyagellátottságnál (The effect of different nutrients upon the variation of leaf unit area transpiration of maize plants). *Növénytermelés* **2**: 239–249.
- Szlovák, S. (1979a): A kukorica transzspirációjának és evapotranszspirációjának vizsgálata (Transpiration and evapotranspiration studies on maize plants). Thesis.
- Szlovák, S. (1979b): A tápanyagellátás hatása a kukorica transzspirációjára (The effect of nutrient supply upon maize transpiration). *VITUKI Közlemények* **28**: 87–90.

STUDY ON THE PHYTOPRODUCTION OF REED CANARY-GRASS SOWN ON SOLONETZ MEADOW-SOIL TYPE

A. Kovács

DEPARTMENT OF PLANT TAXONOMY AND ECOLOGY, EÖTVÖS LORÁND UNIVERSITY,
BUDAPEST, HUNGARY

(Received: 1 January 1982)

Experiments with a sward under intensive treatment, sown with a single species were performed with reed canary-grass (*Typhoides arundinacea*), repeated four times, on meliorated meadow-soil of solonetz type, in the district of Káka of the State Model Farm of Szarvas in autumn 1973. The population collections, yield, root mass of the sward stand, and changes in the composition of the latter were studied for the seven years (1974-1980).

During this period the proportion of the populations of the sown species and species that inhabited the area near them gradually changed and became relatively stabilized due to the natural succession of the sown swards, without having a damaging effect on the structure of the sward stand, and the quality and quantity of yield.

The yield reached the yield level of the sown swards under intensive treatment (40 t/ha green yield and 10 t/ha yield of hay) already in the first year after sowing; then, over four years, it was 60 t/ha green yield and 14 t/ha yield of hay with mowing four times in each growing period. The decrease in yield observed in the last two years of the experiment can be attributed to the three mowings rather than the spot-climate conditions or insufficient supply in nutrients and water. The digestible raw albumin contents of the yield was 12-13% on the average, while the starch content of the yield was 47-49 g/kg on the average.

The root mass measured at the time of the mowing of the different growths, studied in a layer of 0-50 cm of soil, showed a growth and seasonal fluctuation characteristic of the mesophyte sward stands. From the fourth year after sowing a relatively stable root mass developed, which reflected the local soil-climate conditions, the supply of nutrients and water, and also depended on the weight ratio of the phytomasses above and under the ground.

The doses of artificial fertilizers and the irrigation norms may ensure a wide growing of the reed canary-grass (*Typhoides arundinacea*) on meliorized meadow-soil of solonetz type and its utilization as silage or early-mown hay.

Introduction

Extensive home and foreign literature deals with the ecological and cultural conditions of the reed canary-grass (*Typhoides arundinacea*).

The reed canary-grass (*Typhoides arundinacea*) can be found in Central Europe, in the European part of the USSR, in the wooded and wooded-steppe zones, on the plain and in the mountains, mainly on fresh, wet, hard, deep soils but it also occurs on dry podsol, sands, moor, and turf soils. It is a hygromesophilous plant with many ecoforms (DORNER 1912, SHENNIKOV 1944, GRUBER 1954, RABOTNOV 1974, VINCZEFFY 1974). In swards of late-drying soil or of high water table it occurs frequently; sometimes it constitutes a large number of stands. In Hungary it likes mainly the loose soils rich in nutrients (VINCZEFFY 1974). It is also thriving with the full water saturation of the soil if the oxygen supply is ensured, which makes drainage necessary on swamp soil (LOPATIN 1959). It tolerates even an inundation of

30 to 50 days (RAMENSKI 1938), but it best endure the spring flood (HITROVO 1967). It is moderately halophyte, bears a soil brine even of 6–3 mol (RABOTNOV 1974). It is cold-resistant but is sensitive strong frosts (RAMENSKI 1938).

It is deep-rooted (2.5 to 3.5 ms), its thick (1 cm), stoloniferous mycorrhize system of roots makes it suitable for with standing dryness or an inundation coming from above (GRUBER 1954, ANDREYEV 1961, SELIVANOV–UTEMOVA 1962, KURKIN 1966, VINCZEFFY 1974). It is a high plant (50 to 300 cm) with an elongated leafy stem. The young plants are hemicryptophytes while the old ones are geophytes (LINKOLA 1922, RABOTNOV 1974, VINCZEFFY 1974). Throughout the period of their growing the plants have few leaves near the soil. The majority of the leaves can be found at a height of 10–20–30 cm to 60–100 cm on the stem as they require much light of constant intensity (RABOTNOV 1974). Of the plant parts above the ground 75% is constituted by the stem and 25% by the leaves (RABOTNOV 1950). It can grow even 4 to 8 cm daily (KÖNEKAMP). It is a grass showing average development and middle early crop. It reaches its full development in the 3rd or 4th year after sowing (GRUBER 1954). Its transpiration coefficient is 535, which can be decreased by using artificial fertilizer (SCHWARZ 1932). It tolerates an average shading and its longevity can be ensured by fertilization; it makes return for watering (BASKAY–TÓTH 1966).

It is a typical mowing grass but it does not tolerate frequent mowing, lopping off (KLAPP 1971), or being stamped upon by grazing animals (SEREBRYANIKOV 1936, RABOTNOV and DEMIN 1971). When mown young, it is a valuable fodder while mown late, its stem lignifies, roughens (BASKAY–TÓTH 1966). It is of average value as fodder and is mainly suitable for making silage (BARCSÁK 1978). When it is sown, a large amount of artificial fertilizer can be applied to this type of grass the crop of which is, under intensive care, 60–70 t/ha green (SZABÓ 1977) and 30 t/ha dry material, respectively (VINCZEFFY 1974). Recently, species the stems of which tend to lignify less have been developed. Such are e.g. the Szarvas-72 and K-1 reed canary-grasses (JANOVSKY 1977).

On the basis of the above ecologic and cultivation data we set ourselves the task of studying the population collections and crop of the reed canary-grass sward stand sown with a single species, the composition of the yield, the root mass to a soil depth of 50 cm at the time of mowing, and the composition of the roots, on a meadow-soil of solonetz type, under intensive treatment and rainless climate conditions, during an experimental period of seven years.

Material and method

Our sward experiments with an intensive method of treatment, sown with a single species were performed in block K-10 of the grazing land of Plesovszk in the district of Káka of the State Model Farm of Szarvas (Szarvasi Állami Tangazdaság, Kákai kerület, Plesovszki legelő), in parcels of 100 m², repeated four times, with reed canary-grass (*Typhoides arundinacea*), with the species "Szarvasi 50" in the autumn of 1973. Previously, autumn wheat had been grown in this area. Of the 16 days of seed sown with a 12 cm space between the lines in an area of 100 m², 310 000 seedlings had shot up.

The experimental area lies on the north part of the district of Káka of the State Model Farm of Szarvas, about 5 km away from Szarvas. Height above sea level is 84–85 m. The underground water level is rather variable, it is between 1–2 m deep depending on the amount of rainfall, and on the water level in the adjacent irrigation canals. The soil of the field is a sodic soil due to the accumulation of the materials of detrital cones and alluvial deposits of the original Maros and Körös rivers, on lowland degraded loess (hydrocarbonate-sulphate, solontchak, crusty meadow-soil of solonetz type, on muddy aeolian clay) the main characteristics of which are summarized in Table 1. In order to ameliorate this sodic soil artificial fertilizer NPK = 200 : 180 : 280 kg/ha and CaCO₃ of 4500 kg/ha were used in the form of soil- and reserve fertilizer even before sowing. This was followed in October every year by basic manuring with NPD = 100 : 120 : 120 kg/ha and by manuring at the roots, using N = 50 kg/ha in March as well as by a supplementary fertilizer of N = 50 kg/ha after mowing.

Table 1
Characteristic soil data

Depth of the soil samples, cm	pH		Humus, %	Total N, %	P ₂ O ₅	K ₂ O ₅	CaCO ₃ , %	Hard- ness	Total salts, %	Capillary water raising		
	H ₂ O	KCl								mg/100 g	5 h	24 h
0–15	7.10	6.80	3.29	0.17	89.00	86.73	0.42	50	0.20	80	160	
15–30	7.40	7.05	2.48	0.14	43.00	32.52	0	50	0.15	70	175	
30–45	7.55	7.05	3.69	0.09	16.42	21.68	0	59	0.15	50	135	
45–60	7.95	7.20	1.41	0.07	11.20	19.27	0.84	61	0.17	30	115	
60–90	7.50	7.05	0.94	0.04	7.05	19.27	2.95	59	0.40	80	225	

This area belongs to zone A/4, BACSÓ's climate regions with an average rainfall of 500 mm. The evapotranspiration loss of water of 700-800 mm, the great daily and seasonal fluctuations in temperature, and the frequent droughts made irrigation necessary which was 240-320 mm of water in each growing period depending on the rainfall conditions, and this water was supplied by overhead irrigation. From the meteorological data as well as on the basis of the weather-diagrams drawn for the experimental period it can be established that in the course of the seven years of the experiment four years were more rainy, while dry weather and drought predominated in the other three years (Table 2, Fig. 1). The annual average amount of rainfall of 528 mm, characterizing this area, the meadow-soil of solonetz type make only the formation of xerophilous vegetation (*Festucetum pseudovinae*, *Festecetum rupicolae*) possible. The above-mentioned considerable fertilizer doses and the water of irrigation of 320 mm ensured an intensive phytoproduction of the sown grass of long-term, large productivity, with a relative stability of the population collections of the species that planted themselves next to the sown species and became steady.

Grass and root samples were taken four times in each growing period and three times in the last two years of the experiment. Grass yield was measured on the basis of samples taken from 4 × 1 m² parcel by parcel, in green and air-dried states. Root mass was measured by the soil-monolith method, a system elaborated by us (KOVÁCS and GÁSPÁR 1975), to a depth of soil of 0-50 cm. Soil monoliths taken four times were sectionalized in samples of 1 dm³ made of iron sheet, then the roots, after being washed out of them, were measured in both raw and air-dried state. The present study has been made on the basis of the elaboration of 208 raw and air-dried grass samples as well as 2080 raw and air-dried root samples. The soil analyses and investigations of the composition of the yield and roots were carried out in the Irrigation Research Institute of Szarvas. The phytocenological survey of the sward stand was carried out for four years from the 4th year of sowing by plants and in each parcel. Table 3 has been based on the concized evaluation of 64 cenological samples.

Results

Phytocenological conditions of the sward stand

The results of the phytocenological survey of the sown sward stand of reed canary-grass, relating to the years 1977-1980 are summarized in Table 3. It can be established that during the seven years after sowing, the population collections of the sward stand sown with a single species changed considerably. Already by the end of the 3rd year more than ten kinds of grasses, three papilionaceous species and several perennial and annual accompanying species belonging to other families (mainly weeds) populated the area near the sown species. The coverage of the reed canary-grass was 70, 60, 80% on all of the four experimental parcels up to 1979. The hydro-mezophilous species began to grow thin mainly in 1979 and the coverage dropped to 35-60% autumn 1980. Of the perennial species that inhabited the areas near

Table 2
*Characteristic meteorological
Average*

Year/month	Jan.	Feb.	Mar.	Apr.	May
Average for 50 years	-1.7	0.1	5.6	11.2	16.6
1974	0.9	5.3	8.9	9.5	16.7
1975	0.8	-0.5	7.6	10.1	17.5
1976	0.0	-1.6	2.9	13.1	17.0
1977	0.4	5.0	9.1	10.1	18.0
1978	-3.0	0.0	6.4	9.9	13.8
1979	-2.9	1.9	7.5	9.4	17.1
1980	-3.9	0.9	4.8	8.4	13.0

Natural precipitation +

Year/month	Jan.	Feb.	Mar.	Apr.	May	June
Average of 50 years	29	32	33	46	56	59
1974	6.5	21.2	7.4	33.3	76.5	121
Water for irrigation	—	—	—	80	60	40
1975	6.5	3.1	25.7	19.2	85.1	133.2
Water for irrigation	—	—	—	80	60	—
1976	29.8	1.5	37.8	25.6	56	33.3
Water for irrigation	—	—	—	40	40	80
1977	46.3	44.5	45.4	57.1	13.1	33.8
Water for irrigation	—	—	—	—	80	80
1978	9.9	33.1	31.7	32.0	78.0	147
Water for irrigation	—	—	—	80	—	—
1979	54.3	23.1	23.4	23.0	23.0	60.0
Water for irrigation	—	—	—	80	80	80
1980	12.4	23.0	46.3	51.7	111	110.5
Water for irrigation	—	—	—	80	80	80

Humidity,

Year/month	Jan.	Feb.	Mar.	Apr.	May	June
Average for 50 years	85	80	76	68	66	64
1974	86	75	66	62	73	72
1975	88	77	75	74	73	73
1976	75	72	67	54	58	56
1977	80	77	68	64	58	55
1978	81	82	71	70	74	70
1979	85	77	68	72	56	63
1980	82	86	75	72	68	72

Number of

Year/month	Jan.	Feb.	Mar.	Apr.	May	June
Average for 50 years	62	83	140	189	250	272
1974	29.9	92.6	183.3	188.1	199.8	216.8
1975	87.6	142	151	163.8	216.6	225.4
1976	54.8	107.3	138.5	192.9	241.3	285.9
1977	64.9	73.4	175.1	168.9	234.7	251.4
1978	78.2	54.9	156.2	169.6	188.9	250.5
1979	51	82	140	197	267	260
1980	62	61	113	128	181	221

data (Szarvas-Kákafok)
temperature, °C

June	July	Aug.	Sept.	Oct.	Nov.	Dec.
19.7	21.9	21.7	17.1	11.4	5.4	0.4
11.3	19.4	22.0	18.3	8.7	2.9	5.7
18.9	19.7	22.1	19.9	7.1	4.3	—1.9
20.9	23.5	19.5	16.3	12.6	4.7	—1.0
21.4	21.9	20.5	15.0	11.2	5.0	—2.3
18.1	19.0	18.4	14.5	10.4	1.9	1.2
21.9	18.8	19.4	16.9	9.5	5.7	4.0
18.3	19.2	19.8	15.3	11.4	3.6	—0.7

water for irrigation, mm

July	Aug.	Sept.	Oct.	Nov.	Dec.	Sum total	Mar.-Sept.
50	50	40	47	48	38	528	334
47	105.4	24.7	112.8	23.6	21.8	601.2	415.3
60	—	60	—	—	—	300	300
100	68.7	80.2	15.3	7.0	16.3	560.3	512.1
80	80	—	—	—	—	300	300
17.3	13.8	62.2	31.8	40.3	37.5	386.9	246
120	120	—	—	—	—	400	400
36.4	44.4	37.1	4.9	63.7	30.3	457	267.3
—	80	80	—	—	—	320	320
60.0	37.0	21.0	2.3	9.6	47.5	509.9	406.7
80	80	—	—	—	—	240	240
42.0	23.0	8.0	20.9	44.8	42.3	387.8	202.4
—	80	—	—	—	—	320	320
66.2	25.3	9.0	49.0	99.0	24.8	628.2	420
80	—	—	—	—	—	320	320

%

July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average	Mar.-Sept.
59	62	67	73	85	86	73	66
71	76	78	78	82	86	75	71
86	93	89	72	75	85	80	80
50	59	75	78	81	83	67	59
60	68	63	72	70	82	68	62
71	68	74	76	88	86	76	71
67	70	61	66	85	84	71	65
72	70	68	74	85	85	76	71

sunny hours

July	Aug.	Sept.	Oct.	Nov.	Dec.	Sum total
303	278	209	152	75	53	2076
265.8	269.1	220.6	112.8	75.4	69.1	1923.3
264.5	218.9	236.6	137.1	70.4	87.1	2001
285.4	230	139.6	117.1	58.1	71.3	1922.2
234.5	212.4	215.3	158.3	60.3	54.3	1903.5
300.1	258	162.8	176.3	51	47.5	1894
202	232	222	183	41	68	1945
199	275	188	229	69	55.7	1781.7

Table 3

Coenological composition of the introduced sward stand,

Date of sampling			1977			
			9. 5.	13. 6.	13. 7.	30. 8.
Growths			I	II	III	IV
Average cover, %			100	100	100	100
HH	Cpl	<i>Typhoides arundinacea</i>	4	4	3—4	3—4
H	Cpl	<i>Poa pratensis</i>	+	+	+	+
H	Eu	<i>Lolium perenne</i>	+	+	+—1	1—2
Th-TH	M	<i>Lolium multiflorum</i>	+	+	+	+
H	Eua	<i>Dactylis glomerata</i>	+	+	+	+
H	Cpl	<i>Alopecurus geniculatus</i>	+	+	+	+
H	Eua	<i>Alopecurus pratensis</i>	+	+	+	+
G	Eua	<i>Agropyron repens</i>	+	+	+	+
H	Eua	<i>Arrhenatherum elatius</i>	+	+	+	+
H	Eua	<i>Festuca arundinacea</i>	+	+	+	+
H	K	<i>Festuca pseudovina</i>	+	+	+	+
H	K	<i>Bromus inermis</i>	—	—	—	—
Th	Cos	<i>Echinochloa crus-galli</i>	—	—	—	+
Th	Eua	<i>Setaria viridis</i>	—	—	—	+
Th	Eua	<i>Echinochloa spiralis</i>	—	—	—	+
Th	Eua	<i>Bromus mollis</i>	—	—	—	—
H	Eua	<i>Holcus lanatus</i>	—	—	—	—
H	Eua	<i>Trifolium repens, giganteum</i>	+—1	2	2	1
H	Eua	<i>Trifolium pratense</i>	+	+	+	+
H	Eua	<i>Lotus corniculatus</i>	+	+	+	+
H	Eua	<i>Trifolium repens</i>	—	—	—	—
H	Eua	<i>Lathyrus tuberosus</i>	+	—	—	—
H	Cos	<i>Taraxacum officinale</i>	+—1	+	+	+
G	Eua	<i>Cirsium arvense</i>	+	+	+	+
Th	Cos	<i>Geranium pusillum</i>	+	+	+	+
H	M	<i>Podospermum canum</i>	+	+	+	+
Th	Cos	<i>Polygonum aviculare</i>	—	+	+	+
H	Eua	<i>Cichorium intybus</i>	—	—	—	+
H-G	Eua	<i>Convolvulus arvensis</i>	—	+	+	+
Th-TH	Eua	<i>Melandrium album</i>	—	—	—	+
H	Eua	<i>Rumex crispus</i>	—	—	—	+
Th	Cos	<i>Stellaria media</i>	+—1	—	—	+
H	Eua	<i>Achillea setacea</i>	—	—	—	—
Th	Cos	<i>Capsella bursa-pastoris</i>	+—1	—	—	—

(Table 3 continued)

Date of sampling			1977			
			9. 5.	13. 6.	13. 7.	30. 8.
Growths			I	II	III	IV
Average cover, %			100	100	100	100
Th	Adv	<i>Amaranthus albus</i>	—	—	—	+
Th	Cos	<i>Chenopodium album</i>	—	—	—	+
Th	Adv	<i>Lamium purpureum</i>	—	—	—	+
Th	Adv	<i>Conyza canadensis</i>	—	—	—	+
Th	M	<i>Crepis setosa</i>	—	+	+	+
Th	Eua	<i>Lamium amplexicaule</i>	+	—	—	—
Th	Eua	<i>Malva neglecta</i>	—	—	—	+
Th-TH	Eua	<i>Matricaria inodora</i>	—	—	—	+
Th	Adv	<i>Veronica persica</i>	+	—	—	—
H	Cos	<i>Sonchus arvensis</i>	—	—	—	+
Th	Eua	<i>Adonis aestivalis</i>	—	—	—	—
Th	Cos	<i>Amaranthus retroflexus</i>	—	—	—	—
Th	Eua	<i>Chenopodium urbicum</i>	—	—	—	—
H	Eua	<i>Stellaria graminea</i>	—	—	—	—
Th	Cos	<i>Sonchus oleraceus</i>	—	—	—	—
Th	Eua	<i>Atriplex tatarica</i>	—	—	—	—
Th	M	<i>Chenopodium vulvaria</i>	—	—	—	—
Th	Eua	<i>Gypsophila muralis</i>	—	—	—	—
Th	Cpl	<i>Fallopia convolvulus</i>	—	—	—	—
Th	Eua	<i>Matricaria recutita</i>	—	—	—	—
H	Eua	<i>Plantago major</i>	—	—	—	—
H	Eua	<i>Ranunculus repens</i>	—	—	—	—
Th	Cpl	<i>Ranunculus sceleratus</i>	—	—	+	—
Th	Eua	<i>Veronica hederifolia</i>	—	—	—	—
Th	Adv	<i>Veronica polita</i>	—	—	—	—
Species number by growths			23	21	22	35

the sown species, the leptophyllous June-grass (*Poa angustifolia*), the red darnel (*Lolium perenne*) and the horse's foot (*Trifolium repens* f. *giganteum*) continuously increased their numbers of individuals; and their coverage was 5–30% by autumn 1980.

As a result of the natural succession of the sown swards, the number of species of the sward stand was continuously increasing during the experimental period. Several species of weeds also appeared mainly near the perennial Gramineae and Papilionaceae, which are valuable from the point of view of feeding; of these the dandelion (*Taraxacum officinale*) even reached a 5% coverage in some places. In the first growth of 1977, 23 species could be found while in the first growth of 1980 already 30 species occurred. Comparing the species number

1978					1979			1980			
24. 4.	30. 5.	4. 7.	30. 8.	11. 10.	14. 4.	27. 6.	12. 9.	29. 4.	8. 7.	13. 8.	12. 9.
I	II	III	IV	V	I	II	III	I	II	III	IV
100	100	100	100	100	100	100	100	100	100	100	100
—	—	—	+	+	—	—	+	—	—	—	+
—	—	—	+	—	—	+	+	—	—	+	—
—	—	—	+	—	—	—	—	—	—	+	+
—	—	—	+	+	—	—	—	—	—	—	+
—	—	+	—	—	—	—	—	—	—	—	—
+	+	—	—	—	+	—	—	+	—	—	—
—	—	—	+	+	—	—	—	—	—	—	+
+	+	—	—	—	—	—	+	—	—	—	—
+	+	—	—	—	—	—	—	+	—	—	—
—	—	+	+	+	—	—	—	—	—	—	—
—	—	—	—	—	+	+	—	+	—	—	—
—	—	—	—	+	—	—	—	—	—	+	+
—	—	—	+	—	—	—	—	—	—	+	+
+	+	—	—	—	—	—	—	+	—	—	—
—	—	—	—	+	—	—	—	—	—	+	+
—	—	—	+	—	—	—	—	—	+	—	—
—	—	—	—	—	—	+	+	—	—	—	—
—	—	—	+	+	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	+	+
+	+	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	+	+
+	+	—	—	—	—	—	—	—	—	—	—
—	—	+	—	—	—	—	—	—	—	—	—
—	—	—	—	—	+	—	—	+	—	—	—
—	—	—	—	—	—	—	—	1	+	—	—
33	32	29	36	35	31	29	34	34	27	34	37

of the growths in one growing period it can be observed that the lowest number of species could invariably be found in the second growth while the highest number of species occurred in the last growth. The fact that the sward stand became weedy in 7–10% by the end of 1980 does not mean a definite structural degradation.

Consequently, in the 7th year after sowing the sown sward stand of reed canary-grass has achieved, under the given soil-climate conditions and artificial fertilization and irrigation, a relatively stable population collection in spite of the increase in the individual number and coverage of the sown species, which can be illustrated by the life form and chorological spectra of the component species, comparing the years 1977 and 1980.

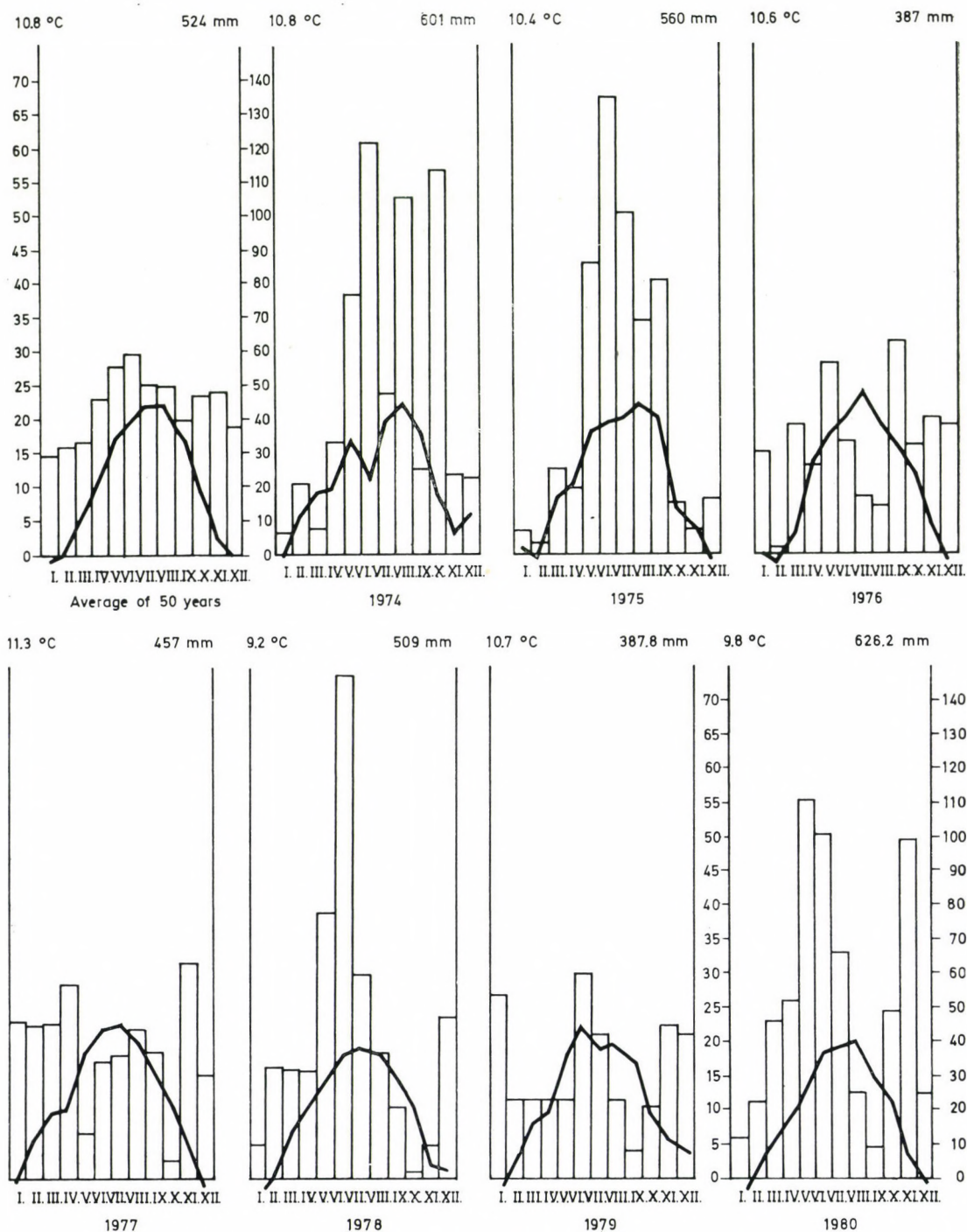


Fig. 1. Climate diagrams for the years 1974–1980 at the Szarvas Kákafok experimental area

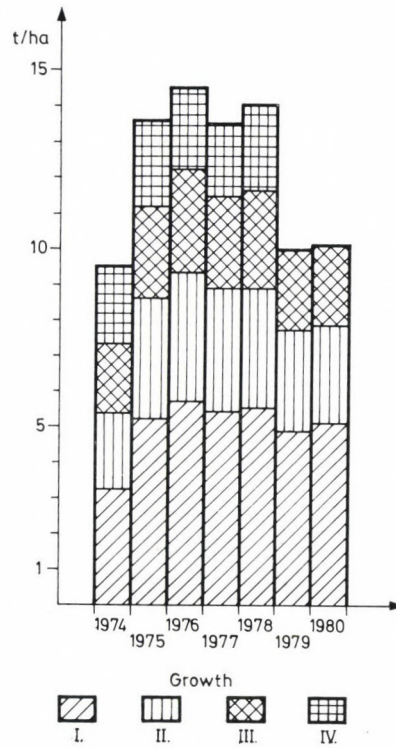


Fig. 2. Change of the yield of hay in the sward stand of *Typhoides arundinacea* in the years 1974–1980

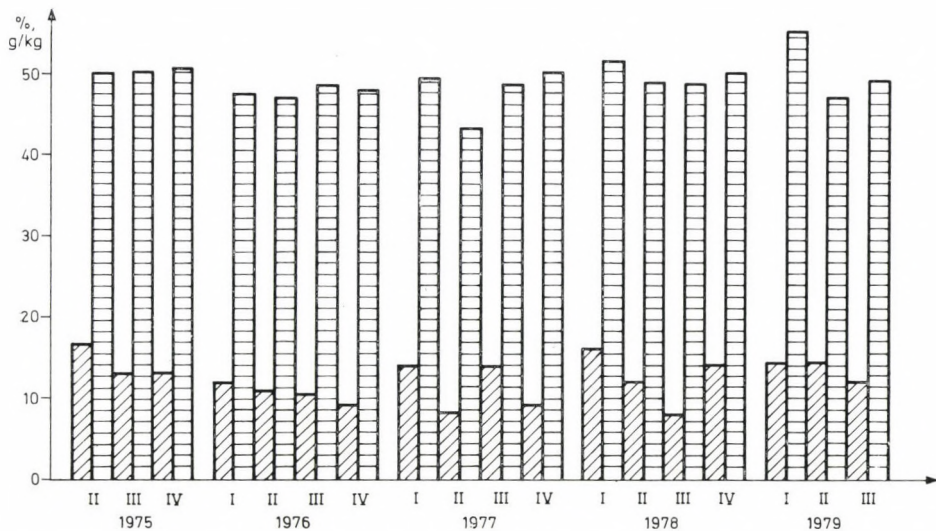


Fig. 3. Digestible albumin (%; cross-hatched columns) and starch (g/kg, white columns) of the yield of sward stands of *Typhoides arundinacea*, according to the growths in the years 1975–1979

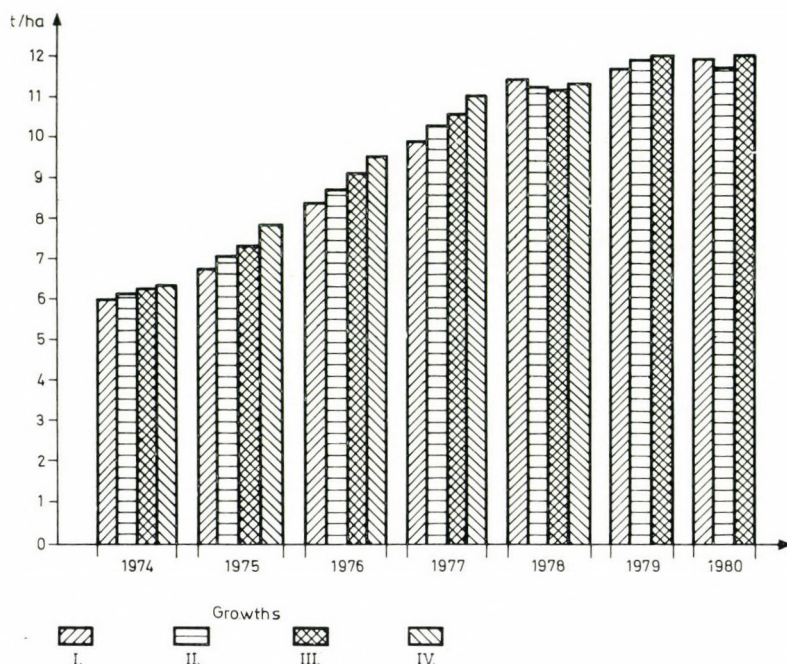


Fig. 4. Changes of the air-dried root mass of the sward stands of *Typhoides arundinacea* at the time of mowing the growths, in 1974–1980

Life form spectrum:

1977: H: 42.5%, H-G: 2.5%, G: 5%, Th-TH: 7.5%, Th: 40%, HH: 2.5%

1980: H: 41.6%, H-G: 2.08%, G: 4.17%, Th-TH: 4.17%, Th: 45.83%, HH: 2.08%

Chorological spectrum:

1977: Cos: 20%, Cpl: 10%, Eua: 47.5%, Eu: 2.5%, Med: 7.5%, Cont: 2.5%, Adv: 10%

1980: Cos: 18.75%, Cpl: 8.33%, Eua: 50%, Eu: 2.08%, Euc: 2.08%, Med: 4.17%, Cont: 4.17%, Adv: 10.42%

Change of yield in the sward stand

The yield of the sward stand of reed canary-grass is illustrated in Table 4 and Fig. 2. This sward stand reached the yield level of the sown swards under intensive treatment already in the first year after sowing, i.e. 40 t/ha green yield and 10 t/ha yield of hay; then, subsequently, an average green yield of 60 t/ha and 14 t/ha yield of hay was maintained over four years, in spite of the dry, rainless growing periods of 1976–1977.

The decrease in yield observed in the years 1979–1980 is not only due to the different precipitation conditions (1979 was dry while 1980 was humid), but also to the grass being mown three times, which resulted in a considerable loss of yield (on average 20 t/ha of green yield and 4 t/ha of yield of hay) as compared with the preceding years when it was mown four times. In case of intensive treatment mowing four times is justified in order to reach the maximum yield.

Table 4

*Yield (in t/ha) of the sown sward stand, the reed canary-grass
(Typhoides arundinacea) in 1974–1980*

Year	Growth I		Growth II		Growth III		Growth IV		Sum total	
	raw	air-dried	raw	air-dried	raw	air-dried	raw	air-dried	raw	air-dried
	mass		mass		mass		mass		mass	
1974	13.665	3.257	9.714	2.265	7.812	1.876	8.876	2.132	40.067	9.530
1975	23.517	5.216	14.813	3.427	9.637	2.437	10.328	2.516	58.295	13.596
1976	25.735	5.671	15.327	3.672	11.221	2.876	11.735	2.361	64.018	14.580
1977	24.872	5.361	15.716	3.528	10.621	2.562	11.371	2.026	62.580	13.477
1978	25.012	5.527	14.837	3.312	11.322	2.761	10.883	2.413	62.054	14.013
1979	19.625	4.813	12.156	2.861	8.962	2.218	—	—	40.743	9.892
1980	21.521	5.134	12.752	2.654	10.811	2.312	—	—	45.084	10.100

As to the quantity of yield of the individual growths, in each case the yield of the first growths was the highest while that of the last ones was the lowest. This was due to the evolution, vitality, and capability for regeneration of the sown species as well as the water supply, at identical levels of nutrient supply.

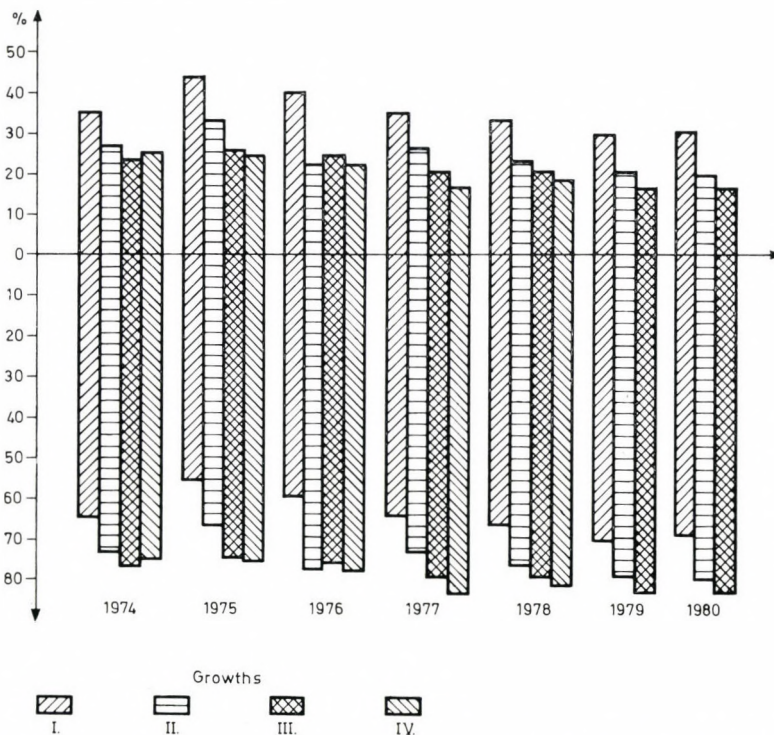


Fig. 5. Percentage of the weight of air-dried above ground and under ground phytomasses in the sward stands of *Typhoides arundinacea*, by growths, in 1974–1980

Table 5
Composition of the yield of Typhoides arundinacea sward stand

Growth No.	Original dry material,	Raw albumin	Raw fat	Raw fibre	Material free from N	Ashes	N	P ₂ O ₅	K ₂ O	CaO	Digestible raw albumin	Value of starch g/kg
%												
1975												
II	100	23.97	1.43	30.27	30.13	14.20	3.84	1.44	4.95	3.04	16.30	49.82
III	100	18.79	2.06	28.76	36.94	13.44	3.00	0.78	3.92	2.06	12.78	50.17
IV	100	18.94	2.10	27.01	38.00	12.86	3.03	1.07	4.47	2.81	12.88	50.84
1976												
I	100	16.52	2.50	26.03	43.38	11.57	2.64	0.89	4.63	3.47	11.23	47.50
II	100	15.74	2.41	25.40	43.44	13.00	2.52	0.92	4.63	2.49	10.71	46.86
III	100	15.05	2.66	23.92	46.09	12.28	2.41	0.85	4.60	2.83	10.23	48.32
IV	100	13.63	1.85	24.34	47.63	12.58	3.81	1.00	5.56	2.98	9.27	47.82
1977												
I	100	20.94	1.79	20.89	44.02	12.36	3.35	1.16	5.33	2.06	14.24	49.46
II	100	11.41	2.10	31.31	41.26	13.92	1.82	1.09	3.52	1.65	7.76	43.26
III	100	20.53	3.03	22.54	41.18	12.72	3.28	0.95	4.37	2.02	13.96	48.61
IV	100	13.78	2.39	24.68	49.48	9.67	2.20	0.88	2.30	1.25	9.37	49.91
1978												
I	100	23.44	2.29	19.84	44.01	10.39	3.75	0.88	4.27	2.17	15.94	51.38
II	100	17.30	1.46	23.24	46.07	11.91	2.76	0.63	4.27	1.81	11.76	48.63
III	100	11.47	2.45	25.93	49.01	11.14	1.83	0.86	3.35	2.05	7.80	48.35
IV	100	19.98	2.24	21.81	44.33	11.64	3.20	1.29	4.00	2.00	13.59	49.64
1979												
I	100	22.40	1.91	21.35	44.70	9.64	3.58	0.97	5.74	3.75	14.32	54.87
II	100	22.60	1.78	24.82	38.27	12.53	3.57	1.19	5.61	6.33	14.45	47.05
III	100	17.29	2.63	24.30	44.73	11.04	2.77	1.35	5.36	4.05	11.76	48.97

Table 6

*Root mass (in q/ha) of the Typhoides arundinacea sward stand
at the time of test mowings*

Soil depth, cm	Growth I		Growth II		Growth III		Growth IV	
	raw weight	air-dried weight	raw weight	air-dried weight	raw weight	air-dried weight	raw weight	air-dried weight
1974	3 May		17 June		6 August		28 September	
0-5	161.362	51.126	168.572	52.828	174.163	53.562	178.963	54.013
5-10	15.773	4.613	14.481	4.235	15.226	4.651	6.142	4.825
10-15	5.221	1.636	5.813	1.842	6.271	1.913	6.724	2.035
15-20	2.944	0.952	3.226	1.051	3.783	1.122	4.017	1.242
20-25	1.713	0.536	2.016	0.612	1.862	0.573	2.016	0.635
25-30	1.061	0.315	1.171	0.345	1.311	0.362	1.425	0.402
30-35	0.406	0.128	0.526	0.135	0.457	0.121	0.482	0.149
35-40	0.273	0.091	0.298	0.102	0.246	0.085	0.317	0.105
40-45	0.131	0.047	0.123	0.041	0.117	0.032	0.141	0.037
45-50	0.028	0.007	0.025	0.008	0.052	0.012	0.042	0.010
Total	188.912	59.451	196.251	61.199	203.488	62.333	200.269	63.454
1975	30 April		20 June		21 July		20 September	
0-5	183.561	57.211	184.826	59.222	189.512	62.231	198.160	66.162
5-10	16.813	5.353	17.235	5.736	18.435	6.113	21.217	6.844
10-15	6.624	2.121	7.144	2.213	7.244	2.327	6.828	2.418
15-20	3.535	1.114	3.953	1.221	4.212	1.338	4.013	1.227
20-25	2.418	0.725	2.018	0.689	1.727	0.716	1.872	0.675
25-30	1.122	0.413	1.421	0.431	1.535	0.452	1.381	0.412
30-35	0.531	0.161	0.431	0.157	0.401	0.126	0.362	0.131
35-40	0.326	0.108	0.361	0.126	0.311	0.097	0.295	0.102
40-45	0.157	0.043	0.164	0.052	0.142	0.036	0.132	0.041
45-50	0.041	0.012	0.038	0.010	0.025	0.008	0.051	0.013
Total	215.128	67.261	217.591	69.857	223.544	73.444	234.311	78.025
1976	10 May		16 June		24 August		16 September	
0-5	221.516	71.482	224.182	74.660	245.328	78.516	256.314	82.326
5-10	21.837	7.037	22.693	7.216	23.172	7.424	22.426	7.232
10-15	7.121	2.313	6.817	2.112	7.081	2.232	8.272	2.413
15-20	4.432	1.324	3.818	1.223	3.457	1.012	3.712	1.118
20-25	2.143	0.641	2.235	0.716	2.446	0.731	2.336	0.718
25-30	1.212	0.395	1.321	0.413	1.416	0.441	1.321	0.461
30-35	0.416	0.156	0.428	0.137	0.372	0.147	0.326	0.135
35-40	0.301	0.087	0.203	0.061	0.221	0.071	0.194	0.063
40-45	0.126	0.031	0.096	0.028	0.117	0.029	0.112	0.035
45-50	0.041	0.011	0.023	0.007	0.026	0.009	0.041	0.011
Total	259.145	83.477	261.816	86.573	283.636	90.612	295.054	94.512
1977	29 April		20 June		19 July		15 September	
0-5	265.316	85.427	276.312	88.613	289.817	92.481	298.424	96.126
5-10	23.527	7.631	23.871	7.827	23.424	7.512	25.131	8.134
10-15	8.438	2.613	9.124	2.838	8.138	2.563	8.452	2.612
15-20	4.427	1.318	5.163	1.441	4.043	1.216	3.813	1.126
20-25	2.382	0.752	2.233	0.731	1.961	0.682	2.412	0.723
25-30	1.426	0.448	1.317	0.412	1.144	0.391	1.335	0.416
30-35	0.526	0.171	0.511	0.165	0.422	0.137	0.453	0.148
35-40	0.341	0.105	0.362	0.112	0.261	0.083	0.234	0.072
40-45	0.127	0.047	0.146	0.051	0.073	0.021	0.112	0.035
45-50	0.046	0.012	0.061	0.014	0.031	0.009	0.046	0.012
Total	306.556	98.524	319.100	102.204	329.314	105.095	340.412	109.404

(Table 6 continued)

Soil depth, cm	Growth I		Growth II		Growth III		Growth IV	
	raw weight	air-dried weight	raw weight	air-dried weight	raw weight	air-dried weight	raw weight	air-dried weight
1978	28 April		30 May		17 July		17 August	
0-5	308.574	99.122	302.712	98.213	300.551	97.557	304.663	98.782
0-10	25.661	8.439	24.363	7.817	25.027	8.271	24.318	8.127
10-15	8.853	2.745	7.881	2.528	8.163	2.613	7.726	2.438
15-20	4.319	1.317	4.072	1.244	4.385	1.328	3.834	1.124
20-25	2.017	0.682	2.327	0.726	2.283	0.731	2.416	0.761
25-30	1.421	0.431	1.251	0.402	1.317	0.424	1.463	0.443
30-35	0.568	0.172	0.424	0.146	0.367	0.135	0.526	0.171
35-40	0.403	0.116	0.326	0.102	0.232	0.075	0.401	0.112
40-45	0.201	0.065	0.162	0.051	0.134	0.044	0.162	0.056
45-50	0.072	0.016	0.034	0.009	0.051	0.012	0.064	0.013
Total	352.089	113.105	343.552	111.238	342.510	111.190	345.573	112.027
1979	12 May		16 July		10 September			
0-5	346.542	101.224	319.838	103.142	323.512	105.352		
5-10	26.353	8.631	28.073	9.327	26.663	8.713		
10-15	9.362	2.818	8.482	2.624	8.071	2.418		
15-20	4.871	1.826	4.416	1.313	3.884	1.261		
20-25	2.627	0.816	2.338	0.762	2.217	0.721		
25-30	1.522	0.437	1.327	0.401	1.346	0.416		
30-35	0.496	0.163	0.427	0.142	0.437	0.134		
35-40	0.348	0.117	0.312	0.104	0.261	0.085		
40-45	0.161	0.046	0.173	0.051	0.091	0.026		
45-50	0.040	0.011	0.034	0.010	0.031	0.009		
Total	362.322	116.089	365.420	117.876	366.513	119.135		
1980	7 May		20 July		17 September			
0-5	320.419	104.561	318.663	102.312	321.660	105.019		
5-10	25.134	8.328	24.842	8.181	25.314	8.427		
10-15	8.143	2.434	8.684	2.620	8.712	2.638		
15-20	3.751	1.212	4.191	1.318	4.361	1.353		
20-25	1.964	0.648	2.236	0.721	2.401	0.736		
25-30	1.127	0.346	1.361	0.413	1.421	0.428		
30-35	0.412	0.124	0.502	0.157	0.519	0.164		
35-40	0.317	0.093	0.300	0.101	0.344	0.112		
40-45	0.139	0.042	0.161	0.056	0.224	0.071		
45-50	0.062	0.013	0.039	0.010	0.063	0.013		
Total	361.468	117.801	360.919	115.889	365.019	118.961		

Composition of the yield

Values of the composition of the yield are shown in Table 5 and Fig. 3. It can be established that the raw fibre contents was highest in growths II and III in each case. The values of the digestible albumin and starch were slightly lower (11-13% and 47-49 g/kg) as compared to other swards under intensive treatment but they were relatively constant during the experimental period. Studying the organic and inorganic components of the yield as a whole, it can be established that they ensure a fodder of average value for animals both in the form of silage and hay.

Changes of root mass

Data relating to the root mass measured at the time of mowing are shown in Table 6 and Fig. 4. It can be established that after sowing, the grass stand continuously increased its root mass over four years then, from the year 1978, it became stabilized, with a slight seasonal fluctuation, at a level of 36 t/ha raw root mass and 11 t/ha air-dried root mass. The continuous concentration of the root mass could also be observed in the upper 10 cm layer of the soil, which was 89% in September, 1974 and 96% in September, 1980. This phenomenon can be explained by the general growth of the sown swards, the massing of the soil as well as the effect of the artificial fertilizer and irrigation water supplied regularly on the soil surface. The continuous increase, then stabilization of the root mass at a level characteristic of swards under intensive treatment also justify the selection of the dose of artificial fertilizer as a function of the water supply. According to the results of our experiments on artificial fertilization of swards and fluid fertilization (KOVÁCS and ANGELI 1977, 1978, 1981, KOVÁCS 1979, 1979) large quantities of the fertilizer N generally cause a decrease in the root mass, and a decrease in yield may occur, mainly under unfavourable water supply conditions. This phenomenon could not be observed in our experiment.

Some characteristics of the composition of the root mass

Data on the composition of the root mass are summarized in Table 7 according to the growths (measurements of 1977) and soil levels (measurements of 1978). According to the data obtained, during the growing period a continuous accumulation of both organic and inorganic materials could be observed in the roots. Studying the composition of the roots in various soil layers it can be established that in roots to be found in the upper level of the soil serving mainly for transport and storage, the quantity of both the organic and inorganic materials is higher than that in the thin roots and rootlets to be found more deeply. If it is accepted that the total root mass is exchanged i.e., mineralized within two years (root change) (RABOTNOV 1974), then it means that of the macro-elements accumulated in the roots a considerable amount gets back into the soil. Thus an opportunity would present itself for decreasing the quantity of the NPK artificial fertilizer used in great quantities every year for swards

Table 7
Composition of the root mass according to growths (1977) and soil levels (1978)

Growth	Dry material	Combustible material	Ashes	C	C : N	N	P ₂ O ₅	K ₂ O	CaO
	%								
I	100	74.14	25.85	37.07	54.51	0.74	0.25	0.38	0.44
III	100	79.47	20.51	39.73	56.75	0.76	0.32	0.98	0.56
IV	100	80.26	19.72	40.13	51.44	0.80	0.26	0.71	1.16
Soil level, cm									
0- 5	100	81.28	18.71	40.63	46.17	0.97	0.26	0.78	0.46
6-25	100	80.11	17.78	40.05	81.84	0.51	0.51	0.55	0.22
26-50	100	76.43	23.56	38.21	47.15	0.23	0.12	0.24	0.16

under intensive treatment and for calculating more accurately the nutrient turnover of a given sward stand. This question is to constitute the subject of further experiments in sward farming.

Weight ratio between the above- and underground phytomasses

The percentage distribution of the weight of the phytomasses above and under the ground according to the growths is to be seen in Fig. 5. It can be established that on a stand level the weight ratio between the phytomasses above and under the ground showed values characteristic of the mesophyte swards even if between these there are considerable discrepancies in absolute value. The weight ratio between the phytomasses above and under the ground was always the smallest with the first growths (1 : 2, 1 : 3), which is the result of the favourable winter and early-spring supply of nutrients and water, while by the end of the growing period this ratio was 1 : 5, 1 : 6 with the last growths, which is in connection with the lack of nutrients and water, increasing from the middle of summer and it could not be considerably modified with irrigation either. Figure 5 also clearly shows that under the influence of a favourable supply of nutrients and water the stand did not increase its root mass even in the droughty years (1976, 1977, 1979); it only showed the seasonal fluctuation characteristic of the root mass growth of Gramineae.

REFERENCES

- Andreyev, N. G. (1961): *Lugovodstvo*. Gosizd. Selsklit. Moscow.
- Barcsák, Z., Baskay-Tóth, B., Priger, K. (1978): *Gyeptermesztés és hasznosítás* (Grassland Cultivation and Grassland Use). Mezőgazdasági Kiadó, Budapest.
- Baskay-Tóth, B. (1966): *Legelő- és rétművelés* (Cultivation of Pastures and Meadows). 2nd ed. Mezőgazdasági Kiadó, Budapest.
- Dorner, B. (1912): *Kaszáló- és legelőjavítás* (Improvement of Meadows and Pastures). Mezőgazdasági Kiadó, Budapest.
- Gruber, F. (1954): *Rét és legelő* (Meadow and Pasture). Mezőgazdasági Kiadó, Budapest.
- Hitrovo, O. V. (1967): Vliyanie zatopeniya vesennimi vodami na poviseniye productivnosti poymennich lugov. Thesis, Moscow.
- Janovszky, J. (1977): A gyepnövények nemesítése és vetőmagtermesztése (Genetic improvement and seed production of grassland plants). In: *A gyepgazdálkodás legújabb eredményei* (Latest Results in Grassland Cultivation). Agroinform, Budapest.
- Klapp, E. (1971): *Wiesen und Weiden*. 4. Aufl., Berlin.
- Kovács, A. (1979a): Fitoproduktions vizsgálatok hígtrágyázott vetett gyepeken (Phytoproduction analyses of fertilized, sowed swards). *Növénytermelés* **28**: 461–472.
- Kovács, A. (1979b): Phytocenological studies on simple species grasses. *Acta Agron. Acad. Sci. Hung.* **28**: 131–149.
- Kovács, A., Angeli, A. (1977): Hígtrágyázott vetett gyepek fitoproduktions vizsgálata a Dunavarsányi Petőfi Mg. Tsz.-ben (Production analysis of fertilized sowed swards in the Petőfi Agronomic Cooperative at Dunavarsány). *Abstracta Bot. Univ. Scient. Budapest* **5**: 91–106.
- Kovács, A., Angeli, A. (1978): Egy fajjal telepített gyepek fitoproduktions vizsgálata az 1974–1976-os években (Phytoproduction analysis of single species artificial swards in the years 1974–1976). *Növénytermelés* **27**: 439–448.
- Kovács, A., Angeli, A. (1981): Phytoproduction of perennial grasses. *Acta Agron. Acad. Sci. Hung.* **30**: 49–60.
- Kovács, A., Gáspár, Z. (1975): Produktions vizsgálatok kultúrnövény állományokban új módszer alkalmazásával (Production studies in crop stands by application of a new method). *Agrártud. Egyet. Közlem. Gödöllő*. 199–206.
- Könekamp, A. (1930): Berichte über die Tätigkeit des Instituts für Grünlandwirtschaft. *Landwirt. Jahrb. Erg. Band*.
- Kurkin, K. A. (1966): Faktori zamknutosti lugovich biogeocenoza. *Trudi MOIP*. 27.
- Linkola, K. (1922): Zur Kenntnis der Überwinterung der Unkräuter und Ruderalpflanzen in der Gegend von Helsingfors. *Ann. Soc. Zool. Bot. Fenn. Vanamo* **1**: 7.

- Lopatin, V. D. (1959): Tipi rezhimov uvlazhneniya i proizvoditelnosti biomassi estestvennoy rastitelnosti. *Soobsh. Sahalinsk. Compl. Nauchn. Issled. Inst.* 8.
- Rabotnov, T. A. (1950): Nekotore voprosi izucheniya structuri lugovich travostoyev. *Bull. MOIP. otdel. Biol.* **55**: 1.
- Rabotnov, T. A. (1974): *Lugovedeniye*. Izd. Moscovsk. Univ., Moscow.
- Rabotnov, T. A., Demin, A. P. (1971): Chislennosti pridatochnik korney kakh priznak structuri lugovich fitotsenozov. *DAN SSSR*. **201**: 1.
- Ramenski, L. G. (1938): *Vvedeniye v kompleksnoye pochvenno-geobotanicheskoye issledovanie zemel*. Moscow.
- Shennikov, A. P. (1941): *Lugovedenie*. Izd. Nauka., Leningrad.
- Schwarz, R. (1932): Untersuchung über den Wasserbrauch verschiedener Gräser. *Arch. Pflanzenbau* 8.
- Selivanov, I. A., Utemova, L. D. (1962): K anatomiu korney osokovikh v svyazi s ikh micotrophnostiu. *Uch. Zap. Permsk. Gosud. Ped. Inst.* 68.
- Serebryanikov, A. V. (1936): *Pastbishchnoye khozyaystvo SSSR*. Moscow.
- Szabó, J. (1977): *Gyepgazdálkodás* (Grassland Economy). Mezőgazdasági Kiadó, Budapest.
- Vinczeffy, I. (1974): *Gyepgazdálkodási ismeretek* (Grassland Economic Informations). Debr. Agron. Univ., Debrecen.

15-N DYNAMIC IN GRASSLAND COMMUNITIES I. INVESTIGATIONS OF THE PLANT SUBSYSTEM IN A SANDY GRASSLAND*

E. N. MOLNÁR, J. N. NOSEK and G. BAKONYI¹

RESEARCH INSTITUTE FOR BOTANY, HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT, HUNGARY

¹ ZOOLOGICAL DEPARTMENT OF AGRICULTURAL UNIVERSITY, GÖDÖLLŐ, HUNGARY

(Received: 15 March, 1983.)

This paper is devoted to the investigations of 15-N flow in the plant subsystem of a sandy grassland community (*Festucetum vaginatae danubiale*). It is a part of an investigation series (FÁBIÁN et al. 1978-79).

On the basis of investigations of several years it could be established that the uptake of the 15-N isotope was influenced in a great degree by the method of putting out and the initial 15-N content of the fertilizer. The characteristics of 15-N uptake curves both in the living and dead plant parts depended on the initial 15-N content. The uptake could be described by the VERHULST-BRODY function in the living parts and by simple logistic one in dead parts.

The initial 15-N enrichment influenced not only the uptake but also the release from all plant compartments. The total release of 15-N isotope from the living parts was about seven years, that from the dead parts was about ten years. From the living parts the release began in the year of fertilization, however from the dead parts only about one year later.

From the point of view of the effect of fertilizer, embedding seems to be more efficient than spraying, considering the recovery values.

Introduction

One of the possible approaches to study the function of biocenoses is to investigate the flow of different elements through the food web. The application of stable nonradioactive isotopes has great advantage in such studies, especially in the field work.

In the course of our investigation series our aims were to study the trophic relationships and to determine the uptake rates of 15-N in the various trophic groups of the plant-arthropods subsystem in a grassland and in an irrigated meadow using 15-N tracer method, as well as to construct the compartment model of the N flow.

In this paper we give an account of the results of the investigations carried out on the plant subsystem. First in order to get a better comprehension it is worthwhile giving a brief summary of the whole study (FÁBIÁN et al. 1977, 1978-79).

Investigations were carried out in a sandy grassland near Vácrátót, North Hungary. The area had been undisturbed for nearly 20 years, neither agricultural activity nor grazing had been done on it. The vegetation was built up of alternating patches of stands of *Festucetum vaginatae danubiale* and *Festucetum wagneri* with a cover between 60-100% depending on the two communities. A detailed floristic list and cenological description has been given by KÁRPÁTI and KÁRPÁTI (1954) and HORÁNSZKY and NAGY (1977).

* "Tece studies" No. 28.

In the arthropod fauna grasshoppers and leafhoppers are of great importance both in number of individuals and in biomass. A detailed description of the fauna can be found in FÁBIÁN et al. (1978-79).

The uptake of ^{15}N was investigated in the following 11 groups of the soil-plant-arthropod system: soil, living plant parts, litter, grasshoppers (Acridida), leafhoppers (Homoptera), mantis (Mantidea), spiders (Araneidea), tiger beetle (Cicindelidae), ant-lion (Myrmeleontidae), ant (Formicidae), darkling beetle (Tenebrionida), locust (Tettigoniidae). (These groups are identical with that of the compartments of the model.)

The relationships in the model (that is the trophic relations) were established on the basis of field observations, gut content analysis (BAKONYI 1980) and the correlation coefficients calculated from ^{15}N values. Correlation coefficients were calculated on two ways: (i) from simultaneous sampling data; (ii) from the shifted sampling data. In the interpretation of the "simultaneous" correlation coefficients it was to be pointed out that a high value might not only mean that the members of an investigated pair consumed each other, but also that both of them consumed the same third member. If the "shifted" correlation coefficient was significantly greater than the adequate "simultaneous" one it denoted a real trophic connection is all probability.

On the basis of the ^{15}N uptake two different paths of nitrogen flow in the subsystem examined could be established. These two paths were identical with two strata, the ground surface and the above-ground part of the community. The uptake rates in the latter stratum were high and on the ground surface stratum were low. These two strata seemed to correspond to the two cenological strata characterized by ants and orthopteras (BALOGH and LOKSA 1948). The results suggested the conclusion that the strata separated in structure were separated in function, too.

Material and methods

Our investigations were carried out in the open sandy grassland (*Festucetum vaginatae danubiale*) from 1976 till 1980. A preliminary experiment was made in 1976 on an unobstructed area of 30×40 m relying on the observation of WIEGERT et al. (1967). The fertilizer (5 g carbamide) containing 50 atomic % ^{15}N was sprayed on a surface of 0.5 m^2 in the middle of the 30×40 m area. Samples were taken from the soil, living and dead above-ground plant parts (the dead parts contained the standing but already dead parts and the litter gathered from the ground surface) and arthropods on six occasions from May 04 till June 09, over 36 days. The soil and plant samples for the ^{15}N content originated from the sprayed area, for the total N content and phytomass they were taken from the unsprayed part of the 30×40 m area. The isotope could be detected reliably only in the plant species, but not in the arthropods.

Therefore, in 1977 a closed experimental box of 4 m^2 made from wire screen of 0.5 mm mesh and glass was set up. Sampling was carried out through two removable small doors. The carbamide fertilizer solution containing 50.4 atomic % ^{15}N was injected into the soil of the box so as to be evenly distributed at a depth of 10 cm. The total amount of the fertilizer was 10 g. Samples were taken from the compartments as in 1976 on nine occasions during the experimental period (May 23-July 6, 45 days). On each occasion we took samples from the box for determining the ^{15}N and total nitrogen content, and others from the area by the box for phytomass.

In 1978 we repeated the experiment but for a more accurate detection of the uptake of ^{15}N a more frequent sampling was applied. The experimental period lasted from June 5 till July 13 (40 days), with daily samplings on odd weeks and sampling twice on even weeks. The carbamide (10 g) contained 30.65 atomic % ^{15}N . Otherwise the experiment was similar to that of in 1977.

The air temperature and the relative humidity in the box did not differ from that of the open area, but the light intensity was 15-25% less in the box.

The release of ^{15}N from living and dead above-ground plant parts was followed on the three places from 1976 till 1979 and/or 1980, taking samples several times in the successive years.

Phytomass samples were taken by harvesting method using 20×20 cm quadrats. After drying at 105 °C and weighing, this material was also used for total nitrogen determination by the KJELDAHL method.

The determination of 15-N was performed using a Statotron NOI-5 Analyzer in the Chemical Dept. of Agricultural University, Gödöllő. The determination was based on emission-spectrophotometry.

In 1976 and 1977 the total above-ground living plant parts were investigated collecting the species singled about in proportion to their biomass and pooled for analysis. The distribution of the phytomass was the following: in 1976: *Festuca vaginata* ≫ *Medicago minima* > *Thymus* sp. > *Carex stenophylla* > *Cynodon dactylon*; in 1977: *Festuca vaginata* ≫ *Euphorbia seguieriana* and *E. cyparissias* > *Carex liparicarpus* and *C. stenophylla* > *Medicago minima* > *Equisetum ramosissimum*.

In 1978 the dominant species were treated separately (*Festuca vaginata*, *Carex liparicarpus* and *C. stenophylla*, *Medicago minima*, *Cynodon dactylon*). As the *Festuca vaginata* gives the majority of the phytomass, only this species is treated in the evaluation.

In the study of the uptake the recovery values were calculated after HAUCK and BREMNER (1976):

$$\frac{100 P(c - b)}{f(a - b)}$$

where P = the total nitrogen in the compartment investigated, f = total nitrogen in the fertilizer, a , b and c are the 15-N atomic % in the fertilizer, in the unfertilized soil (background level) and in the compartment investigated.

To follow the release total N/15-N ratios were calculated (cf. CLARK 1977).

Results

Diurnal and individual variation

The effects of diurnal rhythm and of individual variability on the 15-N uptake was investigated taking samples from five individuals of *Festuca vaginata* at 8.00 a.m., 12.00 and 18.00 p.m. during three days. The samples were separated into living plant parts, standing, but already dead parts, and litter, and then analysed. On the basis of ANOVA it could be established for each group that the timing of sampling within a day had no effect on the 15-N content, in contrast to the individual variability which was significant at 0.1% probability level on each day.

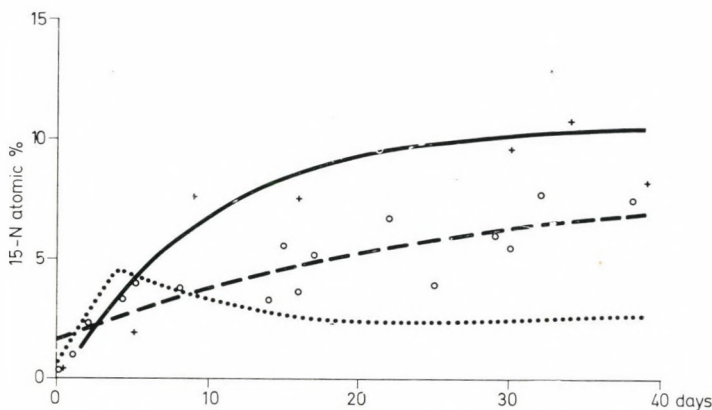


Fig. 1. The fitted uptake curves of 15-N values for the above ground-living compartments in different years (▲..... 1976 above-ground living, hand-fitted curve, +—— 1977 above-ground living, o - - - - - 1978 *Festuca*)

15-N uptake

In the living plant parts 15-N could be detected after a short time in every year. The curve of 1976 differs from that of the other two years (Fig. 1). The uptake in 1977 and 1978 could be approached by the VERHULST-BRODY or monomolecular growth function (Fig. 1). In 1977 the values of the saturation level (A) and the relative uptake rate (c) were greater than in 1978. The slower uptake in 1978 is also reflected in the values of $t_{A/2}$ (Table 1).

In the case of the above-ground dead parts the 15-N values increased continuously till the end of the experimental periods (36, 45 and 40 days after fertilization). Regarding only

Table 1

Parameters of the curves fitted to the 15-N uptake in different compartments and years

Type of function	Compartment	Parameters			$t_{A/2}$ (time in days neces- sary to reach $A/2$)	Signifi- cance of fitting p
		A satura- tion level)	a	c (relative uptake rate)		
VERHULST-BRODY (monomolecular) $y = A(1 - ae^{-cx})$	1977 above-ground living	10.65	1.04	0.104	7.0	0.05
	1978 <i>Festuca</i>	8.52	0.81	0.038	12.9	0.001
Exponential $y = ae^{cx}$	1977 above-ground dead over the experimental period (day 0-40)	—	0.42	0.051	—	0.001
	1978 above-ground dead over the experimental period (day 0-40)	—	0.64	0.022	—	0.001
Simple logistic $y = A \left(\frac{1}{1 + ae^{-cx}} \right)$	1976 above-ground dead over 350 days	4.34	10.57	0.187	12.6	0.001
	1977 above-ground dead over 350 days	4.38	15.78	0.092	30.1	0.001
	1978 above-ground dead over 350 days	3.21	4.25	0.034	42.5	0.001

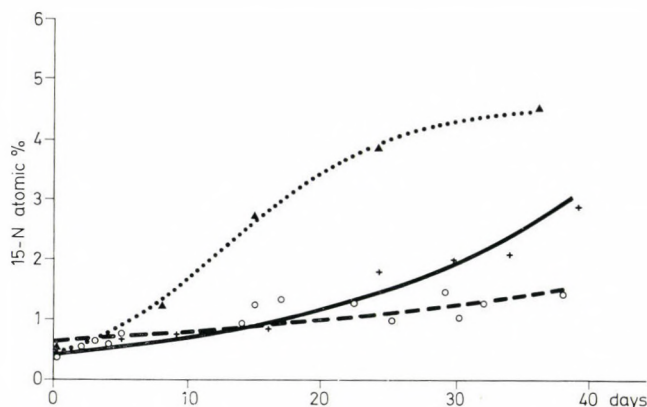


Fig. 2. The fitted uptake curves for the above-ground dead plant part over the experimental period in different years (Δ 1976, +—— 1977, o----- 1978)

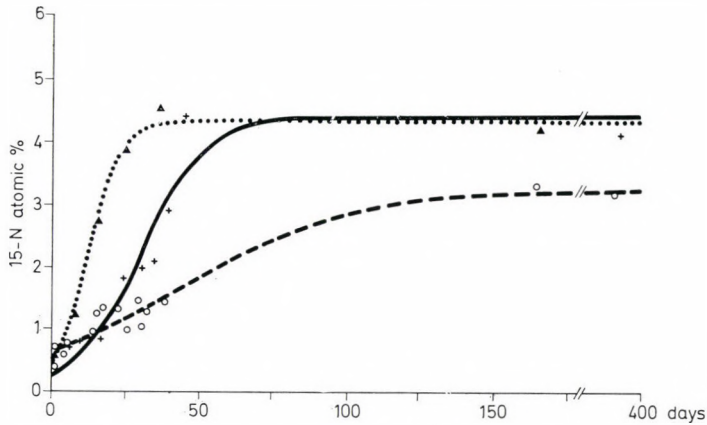


Fig. 3. The fitted uptake curves for the above-ground dead plant parts over a year long period in different years (\blacktriangle 1976, $+$ — 1977, \circ ---- 1978)

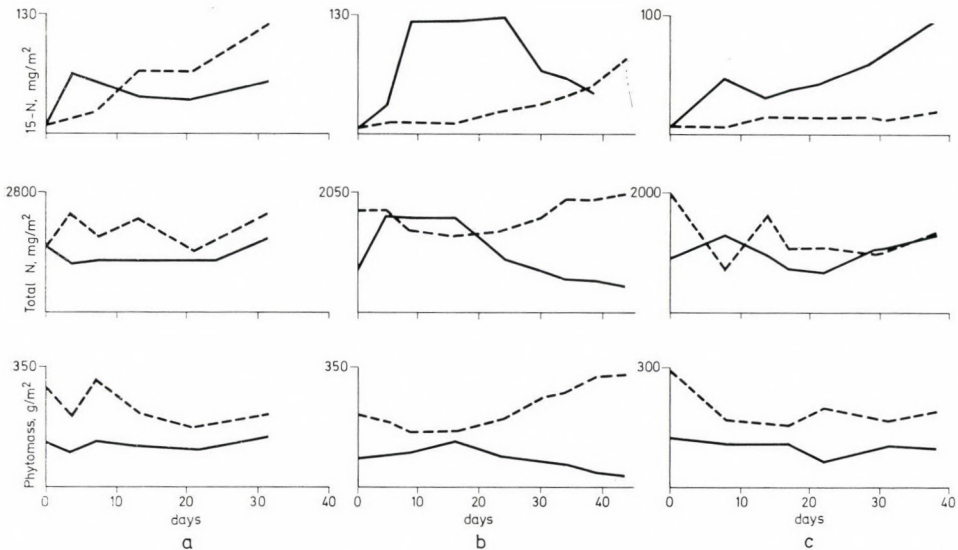


Fig. 4. The phytomass, total nitrogen/m² and total 15-N/m² values over the experimental period in different years (— above-ground living and/or *Festuca* (in 1978), - - - - - above-ground dead, a — 1976, b — 1977 and c — 1978)

this period in 1976 a simple logistic curve, in the other cases (1977, 78) exponential curves could be fitted to the values (Fig. 2). Taking also into consideration next year values over a period of 400 days after the fertilization, in the latter two years the uptake also reached a limit so it can be described by a simple logistic curve (Fig. 3). It is remarkable that a decrease can be detected at the beginning of the next year after the fertilization in all three cases. After this decrease the 15-N atomic % values approached the maximum of the previous year and the real release started only about in the middle of the second year (Figs 5–6). The relative uptake rate was the highest in 1976, as for the others similarly to that of the living parts values of 1977 were higher both in the case of exponential and simple logistic curves.

Table 2

*Recovery values for the uptake period
in the different compartments and years*

	Above- ground living	Festuca	Above- ground dead
1976. 5. 8.	2.5		1.6
5. 12.	2.1		0.7
5. 19.	1.4		2.4
5. 28.	1.3		2.5
6. 9.	2.0		4.4
1977. 5. 28.	3.9		0.9
6. 1.	18.8		0.9
6. 7.	18.8		1.0
6. 15.	19.9		3.2
6. 21.	10.7		4.1
6. 25.	9.5		5.2
6. 30.	6.8		7.7
7. 6.	—		13.1
1978. 6. 13.		11.2	0.8
6. 19.		7.2	2.1
6. 22.		8.9	2.6
6. 27.		10.8	2.6
7. 4.		15.0	2.7
7. 6.		17.2	2.0
7. 13.		24.1	3.6

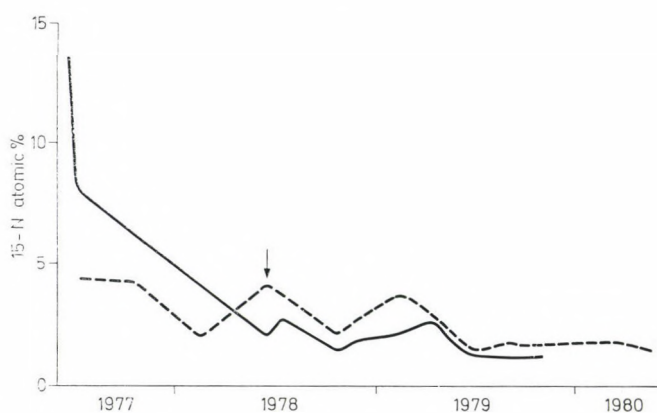


Fig. 5. The hand-fitted curves of the release from different compartments on the plot of 1977 (— above-ground living, - - - - - above-ground dead, the arrow indicates the start of release)

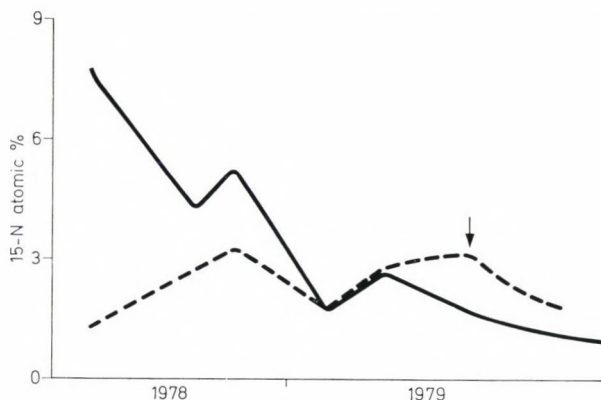


Fig. 6. The hand-fitted curves of the release from different compartments on the plot of 1978 (— *Festuca*, - - - - - above-ground dead, the arrow indicates the start of release)

At the beginning of the uptake the changes in 15-N atomic % play an important part in changes of the 15-N amount (mg/m^2), whereas approaching the saturation level the effects of phytomass and total N content become dominant (Figs 4a, b, c). Comparing the curves of 15-N mg/m^2 values for the dead plant parts they are similar to each other in tendency, but the increase in 1976 is more rapid than in the other two years.

The recovery values are shown in Table 2.

The release of 15-N isotope from the plant parts

The release of 15-N isotope from the living and dead above-ground parts was followed by the samples taken from place of 1977 and 1978 till 1979 and/or 1980 (Fig. 5). The decrease of 15-N content in the dominant plant species (*Festuca vaginata*) was observed over two years (Fig. 6). Here it is to be noted that the preliminary experiment of 1976 is also to be considered as a release from the living parts because of the method of putting out of the isotope.

The process of release can be well represented by the changes in the isotope content. In the above-ground living parts and in *Festuca* the release begins already in the year of fertilization. After an initial rapid phase the release becomes slower and oscillating but gradually approaches the background level.

In the dead parts the release starts only in the next year about 400 days after the fertilization at both places. In the plot of 1978 only the beginning of the release could be observed in lack of further data. The oscillations appear in this compartment, too, and almost coincide with that of the living parts.

The ratio of total N and 15-N refers to the extent of accumulation (cf. CLARK 1977). Table 3 contains these data. If there is a real linear relationship between the data, by linear extrapolation the period necessary for reaching the natural background can be ascertained. The value of the slope is proportional to the release rate. The higher the value of the former, the faster is the release. The fitted linears proved to be significant at 1% or less probability levels (Table 4).

In case of the *Festuca* species if the initial 15-N content of the fertilizer (30.65%) is converted to the value of 1977 (50.4%) the characteristics of the release approaches that of the above-ground living parts in 1977 (Table 4). It is worth mentioning that by using fertilizers of nearly the same 15-N content but different methods of putting them out similar releases are obtained from the above-ground living parts (Table 4).

Table 3

*The N/15-N ratios for the release period
in the different compartments and years*

Date of sampling	Above-ground living	<i>Festuca</i>	Above- ground dead
1976. 5. 8.	22.22		
5. 12.	27.17		
5. 19.	36.97		
5. 28.	41.41		
6. 9.	36.17		
1977. 6. 15.	7.3		
6. 21.	10.5		
6. 25.	9.3		
6. 20.	12.9		
1978. 6. 9.	49.5		24.2
7. 5.	36.1		26.4
7. 7.	—	12.8	—
7. 13.	—	13.4	—
10. 13.	70.4	23.5	49.3
11. 16.	54.3	18.9	37.4
1979. 2. 8.	46.9	58.1	27.2
4. 4.	36.9	37.3	33.8
5. 3.	51.0	—	44.6
6. 19.	82.0	58.8	71.9
8. 21.	89.3	81.3	57.5
9. 14.	86.9	—	62.9
10. 23.	84.0	109.9	59.9
1980. 3. 8.			56.8
5. 4.			71.9

Conclusions

It can be unambiguously established from the studies of the diurnal variations that pooled samples have to be taken for an exact estimation of the 15-N content of all compartments because of the significant variability of individuals.

The uptake of 15-N isotope is influenced to a great extent by the method of application and by the 15-N content of the fertilizer used. The fertilizer sprayed on the leaves is absorbed by the plants, thus owing to the immediate uptake the release begins without delay. Contrarily, if the fertilizer is incorpo-

Table 4

*The release time and rate calculated from the fitted linears
for different compartments and years*

Compartment	Years necessary for total release**	Release rate***	Significance of fitting p
Above-ground living			
from plot 1976	7.73	0.077	0.01
from plot 1977	7.86	0.085	0.001
<i>Festuca</i> 1978	3.72	0.184	0.001
Above-ground dead			
from plot 1977	10.8	0.063	0.001
<i>Festuca</i> 1978*	6.11	0.112	0.001

* From the values converted to the initial 15-N atomic % of 1977 (50.4%)

** In the case of total release $N/15-N = 250$

*** N/15-N increase per day

rated into the soil, the course of the uptake is delayed. The uptake rate and the saturation level are influenced, among others, also by the extent of the initial isotope enrichment (Table 1, Figs 1–3). With spray treatment the isotope gets directly to the dead parts from the living ones (living plant → dead plant parts), however when putting it into the soil the route will be longer because of the uptake from the soil (soil → living plant → dead plant parts). This means that with spraying the transfer from the living parts into the dead parts rather resembles the route soil → living plant parts. This is supported by the parameters of fitted curves, too (Table 1).

In the dead parts similar to the living ones the higher 15-N atomic % of the fertilizer results in higher saturation level and more rapid uptake.

It is clear from the results that the more distant the compartment examined from the initial isotope pool, the longer experimental period must be chosen to establish unambiguously the type of the curve (e.g. in this examination studying the route of soil → living plants → dead plants the one and a half month observation period is too short. By increasing the initial enrichment of the isotope this period becomes shorter.

The changes of release within a year can be brought into connection with the seasonal dynamics of plants, with the nitrogen retranslocation in plants and recycling (Figs 5–6).

CLARK (1977) found in his study 21.3 years for the total release in the above-ground green parts of a shortgrass-prairie on sandy loam with blue grama dominance. Converting his initial 15-N atomic % values (80%) to our 50.4%, this time is 13.5 years. Our investigations produced the values of 7.7 and 7.8 years in an old-field grassland (*Festucetum vaginatae danubiale*) on a

calcareous sandy soil (Table 4). The release of ^{15}N isotope from the dead parts is slower than that of from living parts, which agrees with CLARK's result.

The ^{15}N content of the fertilizer influences considerably the period needed for the total release and the release rate. But there is no effect of the method of putting it out (Table 4).

The recovery of the ^{15}N labelled urea fertilizer is very different depending on the various experimental conditions. The majority of the experiments were performed on cultivated plants under either field or greenhouse conditions. In a field experiment the recovery of N in sorghum grain was only 10.3–11% (MYERS 1979). A higher value, 19.4% was reported by KEENEY and MACGREGOR (1978) in an established ryegrass–white clover pasture. HELTAI et al. (1972) found 64–72% recovery values in oat grown in a greenhouse.

In our study if the fertilizer was embedded, the recovery was greater than with spraying (even if the quantity of the fertilizer per unit area was greater in the latter case). Beside this the amount of recovered ^{15}N increases or remains constant on a higher level for a certain time, but at spraying the values decrease almost immediately (Table 2). This fact is worth taking into account in the practice in connection with soil or foliage fertilization.

REFERENCES

- Bakonyi, G. (1980): Examination of the gut content of *Montana montana* Koll. (Orthoptera). (In Hungarian.) *Folia Entomol. Hung.* **LX 41 (33)**: 361–363.
- Balogh, J., Loksa, I. (1948): Quantitativ-biozoologische Untersuchungen der Arthropodenwelt ungarischen Sandgebiete. *Archiv. Biol. Hung. Ser. II.* **18**: 55–100.
- Clark, F. E. (1977): Internal cycling of ^{15}N nitrogen in shortgrass prairie. *Ecology* **58**: 1322–1333.
- Fábián, Gy., Précsényi, I., Széky, P., Bakonyi, G., Molnár, E., Melkó, E., Nosek, J. (1977): Follow-up of stable ^{15}N isotope flow in the biocenosis of a natural sand-waste grass-plot. (In Hungarian.) *Agrártud. Egy. Közlem., Gödöllő*, 5–12.
- Fábián, Gy., Précsényi, I., Széky, P., Bakonyi, G., Molnár, E. N., Nosek, J. N., Melkó, E. (1978–79): Investigations of ^{15}N flow in a sandy grassland community. *Annal. Univ. Sci. Budap., Sect. Biol.* **20–21**: 17–30.
- Hauck, R. D., Bremner, J. M. (1976): Use of tracers for soil and fertilizer nitrogen research. In: Brady, N. C. (ed.): *Advances in Agronomy*. Acad. Press, New York, **28**: 219–266.
- Heltai, Gy., Kállai, T., Debreczeni, B. (1972): Investigation stable ^{15}N isotope labelled materials using Statron NOI-4 analyser. (In Hungarian.) *Agrártud. Egy. Közlem., Gödöllő*, 93–101.
- Horánszky, A., Nagy, A. H. (1977): Study of assimilation types in species of a sand steppe community. *Acta Bot. Acad. Sci. Hung.* **23**: 91–95.
- Kárpáti, I., Kárpáti, V. (1954): The aspects of the calciphilous turf (*Festucetum vaginatae danubiale*) in the environs of Vác-rátót in 1952. *Acta Bot. Acad. Sci. Hung.* **1**: 129–158.
- Keeney, D. R., MacGregor, A. N. (1978): Short-term cycling of ^{15}N -urea in a ryegrass-white clover pasture. *N. Z. J. Agricultural Res.* **21**: 443–448.
- Myers, R. J. K. (1979): Nitrogen and phosphorus nutrition of dryland grain sorghum at Katherine, Northern Territory. 4. ^{15}N -nitrogen studies on nitrogen carrier and method of application. *Aust. J. Exp. Agric. Anim. Husb.* **19**: 481–487.
- Wiegert, R. G., Odum, E. P., Schnell, H. J. (1967): Forb-arthropod food chains in a one-year experimental field. *Ecology* **45**: 75–83.

PLANT COMMUNITIES OF CUBA, I

FRESH AND SALT WATER, SWAMP AND COASTAL VEGETATION

A. BORHIDI,¹ O. MUÑIZ² and E. DEL RISCO³

¹BOTANICAL RESEARCH INSTITUTE OF THE HUNGARIAN ACADEMY OF SCIENCES,
VÁCRÁTÓT, HUNGARY

²GEOGRAPHICAL INSTITUTE OF THE ACADEMY OF SCIENCES OF CUBA, LA HABANA, CUBA

³BOTANICAL INSTITUTE OF THE ACADEMY OF SCIENCES OF CUBA, LA HABANA, CUBA

(Received: 9 February 1982)

Authors published a systematic review of the higher phytocenological units of the vegetation of Cuba in this periodical (Vol. 25, 1979), and listed the plant associations belonging to each of the higher categories. The series of papers contains the descriptions of the Cuban plant associations mentioned in the cited systematic review, based on their typical samplings. In the first study of the series the fresh and salt water communities and the plant associations of the swamp and coastal vegetation are treated and documented by phytosociological tables. Descriptions of 51 associations are done and 41 of them are first published here.

Introduction

This systematic review is a more detailed and elaborated version of the classification of the vegetation of Cuba, published by BORHIDI, MUÑIZ and DEL RISCO (1979). It is based mainly on the original phytosociological relevés made by BORHIDI, BORHIDI and MUÑIZ, BORHIDI and DEL RISCO, BORHIDI and R. CAPOTE between 1969 and 1979, with a consideration of the vegetation studies and results of (KNAPP 1964, 1965), CUATRECASAS, CHAPMAN, CIFERRI, GÓMEZ-POMPA, HADAČ, DANSEREAU, MONCADA, BALÁTOVÁ, BERAZAIN, SAMEK, SCHUBERT and collaborators, STEHLÉ, STOFFERS, SMITH, VAN CLEEF, VAN DONSELAAR etc. The review contains the first description and original type relevés of many Cuban and Antillean plant communities.

1. Class: **SALVINIO-EICHHORNIETEA** Borhidi and Del Risco 1979

(Syn.: *Cabombo-Eichhornietea* Knapp 1964 p.p.). The free floating phanerogamic vegetation of the neotropical freshwaters, especially in the Caribbean area.

Characteristic species; *Salvinia auriculata*, *S. rotundifolia*, *Azolla caroliniana*, *Lemna minima*, *L. perpusilla*, *Eichhornia crassipes*, *E. azurea*, *E. heterosperma*, *E. diversifolia*, *Pistia stratiotes*, *Aldrovanda vesiculosa*, *Utricularia* spp.

1.1 Order: **SALVINIO-EICHHORNIETALIA** Borhidi 1979

Free floating phanerogamic plant communities of the neotropical areas, formed by not rooted plants floating on the surface of mainly eutrophic freshwater tables.

Characteristic species; *Salvinia auriculata*, *S. rotundifolia*, *Azolla caroliniana*, *Lemna* spp., *Eichhornia* spp., *Pistia stratiotes*.

1.1.1. Alliance: **Azolla-eo-Salvinion** Borhidi and Muñiz 1979

Free floating freshwater vegetation formed by little sized water-pteridophytes and Lemnaceas, covering the surface of lakes, ponds, and slow streams.

Association studied in Cuba:

1.1.1.1. **Lemno-Azolletum carolinianae** Borhidi and Muñiz

Associations of *Lemna perpusilla* and *Azolla caroliniana*, represented in ten relevés (Table 1) made by A. BORHIDI and O. MUÑIZ, in the ponds and

Table 1

Lemno-Azolletum carolinianae Borhidi et Muñiz

	1	2	3	4	5	6	7	8	9	10
Cover, %	60	75	40	50	45	65	60	70	60	55
<i>Lemna perpusilla</i> Torr.	3	3—4	3	2—3	2	2	2—3	4	3	2
<i>Lemna trinervis</i> (Austin) Small.	—	+	—	1	+	—	—	1	—	—
<i>Azolla caroliniana</i> Willd.	2	2	1	2	2	3	3	1—2	2	3
<i>Spirodela polyrhiza</i> (L.) Schleid.	+	—	—	—	—	+—1	—	—	+	—

streams of the Batabano Swamp, S. of Havanna (Dec. 1969) and in the Lake Ariguanabo, SE of Guanajay, La Habana province (Jan. 1970). Type: Relevé No. 2. E. of Batabanó.

1.1.1.2. **Spirodelo-Salvinietum auriculatae** Borhidi and Muñiz

Association of *Salvinia* and Lemnaceae species, represented in 10 relevés (Table 2) made by A. BORHIDI and O. MUÑIZ in the ponds and streams of the

Table 2

Spirodelo-Salvinietum auriculatae Borhidi et Muñiz

	1	2	3	4	5	6	7	8	9	10
Cover, %	70	75	65	80	70	55	70	75	65	60
<i>Salvinia auriculata</i> Aubl.	4.4	4.4	3.4	4.4	4.4	3.3	4.5	4.5	4.4	4.5
<i>Spirodela polyrhiza</i> (L.) Schleid.	1.2	2.2	2.2	2.3	2.2	2.2	1.1	—	+1	—
<i>Salvinia rotundifolia</i>	—	—	—	—	—	—	—	—	—	+1
<i>Lemna perpusilla</i> Torr.	—	+	—	+1	—	—	+1	+1	—	—
<i>Pistia stratiotes</i> L.	+	—	—	—	—	—	—	+	—	—

Batabanó Swamp, in the Lake Ariguanabo and in the Zapata Swamp (Matanzas province), 1969–1970. Type: Relevé No. 7. Zapata-Swamp.

1.1.2. Alliance: **Eichhornion azureae** Borhidi and Muñiz 1979

Free floating freshwater vegetation formed by big sized, not rooted, usually emergent aquatic plants on the surface of eutrophic and oligotrophic lakes and ponds and that of the slow streaming rivers and creeks.

Associations studied in Cuba:

1.1 2.1. **Eichhornietum crassipedis** Samek and Moncada 1971

Water-hyacinth mat association, usually monodominant and nearly monotypic plant community of extreme rush growth and population dynamics. It is represented in 8 relevés; 3 of them made by SAMEK and MONCADA in the white sand area of Cortés (Pinar del Rio province), 1 by BORHIDI in the Rio Hondo (Pinar del Rio province), and 4 by BORHIDI and MUÑIZ in Laguna de Ariguanabo. Type: Relevé No. 1 (Table 3).

Table 3

Eichhornietum crassipedis Samek et Moncada 1971

	1	2	3	4	5	6	7	8
Cover, %	100	100	95	95	100	100	100	100
<i>Eichhornia crassipes</i> (Mart.) Solms.	5.5	3.4	5.5	5.5	5.5	5.5	5.5	5.5
<i>Paspalidium geminatum</i> (L.) Stapf.	+1	2.2	+1	+	+	—	+	—
<i>Vigna</i> sp. (?)	+1	+1	—	—	—	—	—	—
<i>Ludwigia repens</i> Forst. var. <i>repens</i>	+1	—	—	+1	+1	+	+	—
<i>Pistia stratiotes</i> L.	—	—	—	—	+	—	—	—
<i>Spirodela polyrhiza</i> (L.) Schleid.	—	—	—	+1	+	1.1	+1	+1
<i>Azolla caroliniana</i> Willd.	—	—	2.2	—	—	+	—	—
<i>Salvinia auriculata</i> Aubl.	—	—	—	+1	—	—	—	+1

Table 4

Pistietum stratiotidis (Ciferri 1936) Borhidi

	1	2	3	4	5	6	7	8	9	10
Cover, %	100	90	95	80	75	95	70	75	80	95
<i>Pistia stratiotes</i> L.	5.5	5.5	5.5	5.5	4.4	5.5	4.5	4.5	5.5	5.5
<i>Salvinia auriculata</i> Aubl.	1.1	+1	+1	—	—	1.1	1.1	—	+1	—
<i>Spirodela polyrhiza</i> (L.) Schleid.	+1	—	—	+1	—	+1	—	—	+	—
<i>Azolla caroliniana</i> Willd.	+	—	—	—	1.1	—	+1	+1	—	+1
<i>Proserpinaca palustris</i> L.	—	—	—	+1	—	—	—	+1	—	—
<i>Ludwigia peduncularis</i> (Wr. ex Griseb.) Maza	—	—	—	—	—	—	+	—	+	—

1.1.2.2. *Pistietum stratiotidis* (Ciferri 1936) Borhidi

The name of the association of *Pistia stratiotes* was used by CIFERRI (1936: 146) for a special aquatic plant zone in the zonation of a lake with muddy bottom. In his interpretation *Pistia stratiotes* forms a slightly rooted population, but the water-lettuce association is usually a free floating aquatic community, characterized by the following composition (Table 4). The association is represented in 10 phytosociological relevés made by BORHIDI, BORHIDI and MUÑIZ in the Swamp area of Batabanó, Lake Ariguanabo, 1969–1970. Type: Relevé No. 7. Lake Ariguanabo.

1.1.2.3. *Eichhornietum azureae* Borhidi

This water-hyacinth association differs from *Eichhornietum crassipedis* in preferring more oligotrophic and/or dystrophic shallow freshwaters, swamp-lakes, etc. The community is represented in 5 relevés made by BORHIDI in the Zapata Swamp near to Santo Tomás and Laguna del Tesoro, May, 1970. Type: Relevé No. 3 (Table 5).

Table 5

Eichhornietum azureae Borhidi

	1	2	3	4	5
Cover, %	100	100	95	90	95
<i>Eichhornia azurea</i> (Sw.) Kunth.	5.5	5.5	5.5	5.5	5.5
<i>Pistia stratiotes</i> L.	+1	1.1	—	+1	1.1
<i>Salvinia auriculata</i> Aubl.	—	—	+1	—	1.1
<i>Panicum aquaticum</i> Poir.	1.1	+1	+	+1	—
<i>Polygonum hispidum</i> HBK.	+1	+	+	+	+1
<i>Polygonum hydropiperoides</i> Michx.	—	+1	+1	—	—
<i>Azolla caroliniana</i> Willd.	+	—	—	+	—

1.2. Order: ALDROVANDO-UTRICULARIETALIA Borhidi 1979

Aquatic plant communities formed by free-living submerged, mainly carnivorous hydatophytes. Some of the plant species live only slightly submerging under the surface of the water table, and reproductive organs are usually emergent. They occur preferably in eutrophic or more frequently in dystrophic water of the swamp-lakes, bogs and swamp-currents.

Characteristic species: *Aldrovanda vesiculosa*, *Utricularia foliosa*, *U. juncea*, *U. brevifolia*, *U. sclerocarpa*, *U. stellaris*, *U. cornuta*, *U. resupinata*, *U. olivacea*, *U. incisa*, *U. purpurea*, *U. virgatula*, etc.

1.2.1. Alliance: *Aldrovando-Utricularion* Borhidi 1979

Characteristics of the order. Communities studied in Cuba:

1.2.1.1. *Utricularietum foliosae* Borhidi

Free floating submerged water plant community formed by bigger sized carnivorous plants living mostly in deeper dystrophic or eutrophic swamp lakes of neutral or basic freshwater. The association is represented in 5 relevés made by A. BORHIDI in the Lake Ariguanabo and in the Zapata Swamp area. Type: Relevé No. 2. Lake Ariguanabo, 1970 (Table 6).

1.2.1.2. *Utricularietum junceae* Borhidi

Free floating submerged water plant community formed by medium or little sized carnivorous plants living mostly in shallow dystrophic or oligotrophic freshwaters of neutral or slightly acidic chemical reaction. The association is represented in 5 relevés made by A. BORHIDI in the W-Cuban white sand lake area. Type: Relevé No. 2. Laguna Santa Maria (Pinar del Rio province) March, 1976 (Table 7).

1.2.1.3. *Utricularietum resupinatae* Borhidi

Free floating or partly rooted water plant community formed by little sized carnivorous plants living in the shallow sublittoral sandy shore of the

Table 6
Utricularietum foliosae Borhidi

	1	2	3	4	5
Cover, %	45	50	60	40	55
<i>Utricularia foliosa</i> L.	3.4	3.3	4.5	2.3	3.4
<i>Utricularia mixta</i> Barnh.	+1	2.2	—	1.1	1.2
<i>Ludwigia erecta</i> (L.) H. Hara	—	—	1.1	1.1	—
<i>Spirodela polyrhiza</i> (L.) Schleid.	—	+1	1.1	—	—
<i>Salvinia auriculata</i> Aubl.	—	+1	—	—	1.1

Table 7
Utricularietum junceae Borhidi

	1	2	3	4	5
Cover, %	50	55	45	60	50
<i>Utricularia juncea</i> Vahl.	3.2	3.3	3.3	3.3	3.3
<i>Utricularia virgatula</i> Barnh.	+1	—	—	—	—
<i>Utricularia pusilla</i> Vahl.	—	—	1.1	+1	—
<i>Utricularia pumila</i> Walt.	—	+1	—	—	—
<i>Bulbostylis tenuifolia</i> McBr.	1.2	+1	—	1.2	1.1
<i>Bulbostylis capillaris</i> (L.) C. B. Clarke	+1	—	1.1	—	—

Table 8
Utricularietum resupinatae Borhidi

	1	2	3	4	5
Cover, %	45	55	60	40	45
<i>Utricularia resupinata</i> B. D. Greene	3.2	3.3	4.3	3.2	3.3
<i>Utricularia pumila</i> Walt.	+1	1.1	1.1	—	+1
<i>Utricularia sclerocarpa</i> Wr. in Sauv.	+1	+1	—	—	—
<i>Bulbostylis tenuifolia</i> McBr.	1.2	1.1	2.2	+2	1.1
<i>Bulbostylis arenaria</i> Lindm.	—	—	+1	+1	—
<i>Caperonia cubana</i> Pax. et Hoffm.	—	+1	—	—	—

Table 9
Mayacetum fluviatilis Borhidi

	1	2	3	4	5
Cover, %	90	100	90	95	100
<i>Mayaca fluviatilis</i> Aubl.	5.5	5.5	5.5	5.5	5.5
<i>Fimbristylis annua</i> (All.) R. et S.	+2	1.1	+1	+1	—
<i>Eleocharis elegans</i> (HBK.) R. et S.	+1	—	+1	—	+1
<i>Anemia nipensis</i> Benedict.	+1	—	+1	—	—
<i>Utricularia pusilla</i> Vahl	+1	+1	—	+1	—
<i>Heptanthus lobatus</i> Britt.	—	+1	—	—	+1
<i>Koehneola repens</i> (Griseb. ex Urb.) Urb.	—	—	+1	+1	—

lakes of oligotrophic and usually acidic freshwater. The association is distributed all over the W-Cuban wet land of the Isthmus of Guanahacabibes, and it is represented with 5 relevés made by A. BORHIDI and Ramona OVIEDO, March 1976. The association is characterized by a community of little sized *Utricularia* and *Bulbostylis* species. Type: Relevé No. 2, Laguna del Jovero, cerca de Sandino (Pinar del Rio province) (Table 8).

1.3. Order: MAYACETALIA FLUVIATILIS Borhidi 1979

Aquatic submerged, occasionally amphibic plant communities formed by the dense sward of moss shaped rooted phanerogamic plants living in the transitional littoral zone of montane, rush current creeks and oligotrophic lowland lakes. The communities are distributed throughout the neotropical region.

Characteristic species: *Mayaca fluviatilis*, *M. fluviatilis* ssp. *wrightii*, *Utricularia sclerocarpa*, *U. cleistogama*, *U. cornuta*, etc.

1.3.1. Alliance: **Mayacion fluviatilis** Borhidi 1979

Characteristics of the order. Associations studied in Cuba:

1.3.1.1. **Mayacetum fluviatilis** Borhidi

Submerged rock pavement vegetation along the montane creek-sides and river-sides in the mountains of Oriente, especially on serpentine rocks. *Mayaca fluviatilis* is monodominant, among the companions can be find several endemics. The association is represented in 5 relevés made by A. BORHIDI in the Sierra de Nipe (Rio Piloto, Rio del Medio, Rio Guayabo). Type: Relevé No. 1 (Table 9) from the Rio Piloto, 19 July 1970.

1.3.1.2. **Mayacetum wrightii** Borhidi

Dense, permanently or seasonally submerged littoral sward on the shore of the oligotrophic lakes in the wetlands of the white sand areas of W-Cuba and Isle of Pine. *Mayaca fluviatilis* ssp. *wrightii* is characteristic, morphologically distinct ecotype of the white sand areas. Type: Relevé No. 2 (Table 10) from the laguna de la Máquina, Pinar del Rio province, made by A. BORHIDI and Ramona OVIEDO, March 1976.

2. Class: **CABOMBO-NYMPHAEETEA** Borhidi and Del Risco 1979

(Syn.: *Cabombo-Eichhornietea* Knapp 1964 p.p.). Aquatic vegetation of the neotropical freshwaters, formed by rooted hydatophytes submerged or emerged, in the different ecological types (eutrophical, oligotrophical and dystrophical) freshwaters.

Characteristic species: *Brasenia peltata*, *B. schreberi*, *Cabomba aquatica*, *C. piauhyensis*, *Hydrocotyle umbellata*, *Nymphaea* spp., *Potamogeton* spp., *Myriophyllum sparsiflorum*, *M. verticillatum*, *Nymphoides* spp., etc.

2.1. Order: **CABOMBO-NAJADETALIA** Borhidi and Del Risco 1979

(Syn.: *Utriculario-Najadetalia* Knapp 1964 p.p.). Neotropical aquatic vegetation formed by submerged and rooted plants in the standing or slowly current freshwaters, sometimes also in slightly saline brackish waters.

Characteristic species: *Cabomba* spp., *Ceratophyllum demersum*, *Myriophyllum pinna-tum*, *M. sparsiflorum*, *Najas marina*, *N. microdon*, *Vallisneria americana*, *V. neotropica-lis*.

2.1.1. Alliance: **Vallisnerion americanae** Borhidi and Del Risco 1979

Subaquatic freshwater swards formed by rooted submerged aquatics with ribbon-like leaves mostly in eutrophic or slightly dystrophic lakes, rarely also in slightly saline waters.

Associations studied in Cuba:

Table 10

Mayacetum wrightii Borhidi

	1	2	3	4	5
Cover, %	100	100	90	100	100
<i>Mayaca fluviatilis</i> ssp. <i>wrightii</i> (Griseb.) Borhidi	5.5	5.5	5.5	5.5	5.5
<i>Eleocharis interstincta</i> (Vahl) R. et S.	1.1	+1	—	1.1	1.2
<i>Eleocharis capillacea</i> Kük.	—	+1	1.1	+1	—
<i>Eleocharis minima</i> Kunth	+1	+1	—	—	—
<i>Eriocaulon lacustre</i> Ruhl.	—	+1	+1	—	—
<i>Pinguicula filifolia</i> (Wr. ex Griseb.)	—	+2	—	+2	—
<i>Rhynchospora cyperoides</i> (Sw.) Mart.	+2	+1	1.1	+2	+1
<i>Scirpus confervoides</i> Poir.	+2	+2	+1	1.2	—
<i>Rhynchospora tracei</i> Britt.	—	—	—	+2	+1
<i>Utricularia juncea</i> Vahl	+2	+2	+1	1.2	—
<i>Andropogon</i> sp.	—	—	—	+2	—

2.1.1.1. *Vallisnerietum americanae* Borhidi and Muñiz

Submerged aquatic, monodominant dense sward of *Vallisneria americana* with very few companion species. The association is known also from Florida and SE. United States. It is represented in 5 relevés made by A. BORHIDI and O. MUÑIZ in the Rio Zaza (Sancti Spiritus province), July 1970. Type: Relevé No. 3 (Table 11).

Table 11

Vallisnerietum americanae Borhidi et Muñiz

	1	2	3	4	5
Cover, %	100	100	100	100	100
<i>Vallisneria americana</i> Michx.	5.5	5.5	5.5	5.5	5.5
<i>Hydrocotyle umbellata</i> L.	+1	+1	+1	—	+1
<i>Potamogeton nodosus</i> Poir.	—	—	+1	+1	—

2.1.1.2. *Vallisnerietum neotropicalis* Borhidi and Del Risco

Subaquatic dense sward formed almost exclusively by *Vallisneria neotropicalis*. The association is very distributed and common in the Laguna del Tesoro (Zapata Peninsula, Matanzas province). It is represented with 5 relevés made by A. BORHIDI and E. DEL RISCO, October 1974. Type: Relevé No. 2 (Table 12).

Table 12

Vallisnerietum neotropicalis Borhidi et Del Risco

	1	2	3	4	5
Cover, %	100	100	100	100	100
<i>Vallisneria neotropicalis</i> M. Vict.	5.5	5.5	5.5	5.5	5.5
<i>Utricularia foliosa</i> L.	+1	+1	+1	1.1	—
<i>Hydrocotyle umbellata</i> L.	—	1.1	—	—	+1
<i>Panicum geminatum</i> Forsk.	—	—	—	—	+1
<i>Potamogeton nodosus</i> Poir.	—	—	+1	+1	—

Table 13

Cabombetum piauihyensis Borhidi et Muñiz

	1	2	3	4	5
Cover, %	70	75	80	70	65
<i>Cabomba piauihyensis</i> Aubl.	4.4	4.4	4.5	4.5	4.4
<i>Proserpinaca palustris</i> L.	1.1	—	+1	—	—
<i>Potamogeton nodosus</i> Poir.	—	—	+1	+1	—
<i>Myriophyllum sparsiflorum</i> C. Wr. ex Sauv.	+1	—	—	—	—
<i>Ludwigia inclinata</i> (L. f.) H. Hara	—	+1	—	—	+1
<i>Ludwigia erecta</i> (L.) H. Hara	+1	—	+1	—	—
<i>Utricularia mixta</i> Barnh.	—	+1	+1	—	—

2.1.2. Alliance: *Ceratophyllo-Cabombion piauihyensis* Samek and Moncada 1971

Neotropical aquatic vegetation formed by submerged and partly emerged plants of palmate- and pinnatesected leaves in eutrophic or moderately oligotrophic lakes.

Associations studied in Cuba:

2.1.2.1. *Cabombetum piauihyensis* Borhidi and Muñiz

The monodominant submerged plant community of the *Cabomba piauihyensis* only with some accident companions. It is represented with 5 relevés made by A. BORHIDI and O. MUÑIZ in the Laguna Ariguanabo near to Guanajay (Habana province), January 1970. Type: Relevé No. 1 (Table 13).

2.1.2.2. *Nymphaeo-Cabombetum piauihyensis* Samek and Moncada 1971

The association is formed by two layers: the submerged layer of *Cabomba* and the emergent layer of the water-lilies with large, entire floating leaves.

The community is represented with 5 relevés, all made in white sand wetland of W-Cuba, two by SAMEK and MONCADA in Santa Lucia, three others by A. BORHIDI and Ramona OVIEDO in the Alcatraz Mayor (3-4-5). Type: Relevé No. 1 (Table 14).

2.2. Order: NYMPHAEETALIA AMPLAE Knapp 1964

Aquatic vegetation formed mostly by rooted large sized emergent hydatophytes with floating leaves. The communities belonging to this sociological unit live in shallow eutrophic, oligotrophic and dystrophic freshwaters.

Characteristic species: *Brasenia schreberi*, *Nymphaea ampla*, *N. blanda*, *Nuphar luteum* ssp. *macrophyllum*, *Hydrocotyle umbellata*, *Nelumbo lutea*, *Nymphoides humboldtiana*, *N. graryana*, *Potamogeton* spp.

2.2.1. Alliance: **Potamion illinoensis** Borhidi 1979

Slightly emergent, densely closed aquatic swards mostly in eutrophic, slowly current freshwaters.

Table 14

Nymphaeo-Cabombetum piauihyensis Samek et Moncada 1971

	1	2	3	4	5
Cover, %	90	75	80	75	85
<i>Cabomba piauihyensis</i> Aubl.	3.3	3.3	3.3	4.4	4.5
<i>Nymphaea odorata</i> Dryand	4.5	3.2	2.3	1.3	2.2
<i>Nymphoides aureum</i> (Britt.) Britt. et Millsp.	—	+1	+1	1.1	1.1
<i>Ludwigia inclinata</i> (L. f.) H. Hara	—	—	+1	+1	—
<i>Salvinia auriculata</i> Aubl.	—	—	—	+1	+1
<i>Hymenachne amplexicaulis</i> (Rudge) Nees.	—	—	+1	—	—

Table 15

Potametum illinoensi-nodosi Borhidi et Muñiz
(*Potametum nodosi-malaini* Borhidi et Muñiz)

	1	2	3	4	5
Cover, %	70	75	80	60	70
<i>Potamogeton illinoensis</i> Morong	3.3	3.4	5.5	3.3	3.4
<i>Potamogeton nodosus</i> Poir.	3.4	3.2	—	1.3	2.3
<i>Utricularia foliosa</i> L.	—	+1	1.1	—	—
<i>Hydrocotyle umbellata</i> L.	+1	+1	—	—	—
<i>Vallisneria neotropicalis</i> M. Vict.	—	—	1.1	2.2	—
<i>Paspalidium paludivagum</i> (L.) Stapf	+1	—	—	—	—

Table 16
Nymphaeo-Potametum nodosi Borhidi

	1	2	3	4	5
Cover, %	100	90	95	80	100
<i>Potamogeton nodosus</i> Poir.	5.5	5.5	5.5	5.5	5.5
<i>Nymphaea ampla</i> (Salisb.) DC.	2.2	2.2	1.3	2.2	—
<i>Sagittaria lancifolia</i> L.	1.2	—	+1	—	+1
<i>Utricularia foliosa</i> L.	1.2	+1	—	1.1	—
<i>Utricularia mixta</i> Barnh.	—	—	—	—	+1
<i>Proserpinaca palustris</i> L.	—	—	—	+	—

Table 17
Hydrocotyletum umbellati Del Risco

	1	2	3	4	5
Cover, %	60	70	75	80	70
<i>Hydrocotyle umbellata</i> L.	3.3	3.4	4.4	4.5	3.3
<i>Utricularia foliosa</i> L.	+1	+r	—	—	—
<i>Vallisneria neotropicalis</i> M. Vict.	1.1	2.2	2.2	4.4	+1
<i>Scirpus validus</i> (Vahl) T. Koyama	—	+1	—	1.1	1.1
<i>Paspalidium paludivagum</i> (L.) Stapf	—	—	+1	+r	—
<i>Polygonum punctatum</i> Ell.	1.1	—	—	—	—

Associations studied in Cuba:

2.2.1.1. *Potametum illinoensi-nodosi* Borhidi and Muñiz

A rather dense aquatic plant community formed by two mostly co-dominant *Potamogeton* species. It can be found mainly in the sublittoral zone of the slowly current lowland rivers and drainage ditches of wetlands and swamp areas. The 5 representative relevés (Table 15) were made by A. BORHIDI and O. MUÑIZ in the Zapata Swamp, May 1970. Type: Relevé No. 2. Laguna del Tesoro.

2.2.1.2. *Nymphaeo-Potametum nodosi* Borhidi

An aquatic plant community, similar to the former one, but it occurs frequently in contact with it in shallower freshwater, on muddier bottom, replacing mostly shorewards the former association in the zonality. The representative 5 relevés were made by A. BORHIDI and O. MUÑIZ at the same localities and data. Type: Relevé No. 1. Zapata Swamp near Buenaventura (Table 16).

2.2.1.3. *Hydrocotyletum umbellati* Del Risco

A very common plant community of *Hydrocotyle umbellata*, formed usually in the transitional zone between water-lily mat and littoral sedge marsh or reed-grass marsh communities. It is usually composed of two layers, a submerged and an emergent one. The submerged dominant can be *Vallisneria*, *Najas*, *Potamogeton*, *Ceratophyllum* and others. Five representative relevés (Table 17) were made by E. DEL RISCO and A. BORHIDI in the Laguna del Tesoro, near Guama (Zapata Swamp), in October and November 1974. Type: Relevé No. 4.

2.2.1.4. *Myriophylletum sparsiflori* Borhidi

This community is a very characteristic association of the little, shallow white sand lakes, forming the inner belt of the rooted aquatic vegetation. It can be found in slightly oligotrophic, shallow freshwaters on sandy bottom. Representative relevés (Table 18) made by A. BORHIDI and Ramona OVIEDO

Table 18
Myriophylletum sparsiflori Borhidi

	1	2	3	4	5
Cover, %	70	80	90	85	95
<i>Myriophyllum sparsiflorum</i> C. Wr. ex Sauv.	3.4	4.4	4.5	4.4	4.5
<i>Proserpinaca palustris</i> L.	1.2	2.2	+1	1.1	—
<i>Cabomba piauhyensis</i> Aubl.	1.1	—	—	—	1.2
<i>Utricularia foliosa</i> L.	2.2	—	1.1	—	—
<i>Utricularia mixta</i> Barnh.	—	1.1	—	—	—
<i>Mayaca fluviatilis</i> ssp. <i>wrightii</i> (Griseb.) Borhidi	—	—	—	1.1	—

Table 19
Brasenetum schreberi Borhidi

	1	2	3	4	5
Cover, %	80	75	90	85	70
<i>Brasenia schreberi</i> Gmel.	4.5	4.5	5.5	4.5	3.3
<i>Nymphaea ampla</i> (Salisb.) DC.	—	+1	—	—	1.2
<i>Nuphar luteum</i> (L.) Sibth. et Sm.	+1	+1	—	+1	—
<i>Potamogeton nodosum</i> Poir.	+1	—	—	—	—
<i>Utricularia foliosa</i> L.	—	—	2.2	—	1.2
<i>Websteria confertifolia</i> (Poir.) T. Koy.	—	—	—	—	1.2
<i>Eleocharis interstincta</i> (Vahl.) R. y S.	—	—	—	—	1.1

in the white sand wetland of W-Cuba, March, 1976. Type: Relevé No. 4. Laguna Alcatraz Chiquito, near Cortés (Pinar del Rio province).

2.2.2. Alliance: **Nelumbio-Nymphaeion amplae** Samek and Moncada 1971

Emergent freshwater vegetation formed by water-lily mats and by other large-sized rooted aquatic plants with large floating or emergent leaves and showy flowers. The communities belonging to this alliance grow in all types of freshwaters, but more frequently in dystrophic and oligotrophic ones.

Associations studied in Cuba:

2.2.2.1. **Brasenetum schreberi** Borhidi

Emergent, rooted freshwater plant community living mostly in the inner side of the water-lily mats, in somewhat deeper water and on muddy substrate. *Brasenia* is monodominant, the companions are the dominant species of the neighbour communities of the zonation. Five representative relevés were made by A. BORHIDI in the Ariguanabo lake, January, 1975. Type: Relevé No. 3 (Table 19).

2.2.2.2. **Nymphaetum amplae** Borhidi and Muñiz

Association of the very common water-lily mats of the Antilles and tropical America, mentioned but not analyzed by CIFERRI (1936) and DAN-SEREAU (1966). This community is widely distributed in eutrophical and distrophical lakes, ponds, dead arms of rivers etc. Five representative relevés made by BORHIDI and MUÑIZ in the Lake Ariguanabo near Guanajay, January, 1970. Type: Relevé No. 3 (Table 20).

2.2.2.3. **Nupharetum macrophylli** Borhidi and Del Risco

Avicariant association of the water-lily mat in shallower, more dystrophic freshwater and muddier sites. Somewhere it is in contact shorewards with

Table 20

Nymphaetum amplae Borhidi et Muñiz

	1	2	3	4	5
Cover, %	80	90	85	90	80
<i>Nymphaea ampla</i> (Salisb.) DC.	4.4	5.5	5.5	5.5	5.5
<i>Brasenia schreberi</i> Gmel.	2.2	—	—	—	—
<i>Nuphar luteum</i> ssp. <i>macrophyllum</i> (Small) Beal.	—	1.1	—	+1	—
<i>Potamogeton nodosus</i> Poir.	—	+1	2.2	—	2.2
<i>Utricularia foliosa</i> L.	2.2	—	1.1	1.1	+2
<i>Eleocharis interstincta</i> (Vahl.) R. y S.	+1	+1	—	—	+1
<i>Ludwigia erecta</i> (L.) H. Hara	—	+1	—	—	—

Table 21
Nupharetum macrophylli Borhidi et Del Risco

	1	2	3	4	5
Cover, %	80	70	85	65	75
<i>Nuphar luteum</i> ssp. <i>macrophyllum</i> (Small) Beal.	4.4	3.3	5.5	4.4	4.5
<i>Nymphaea ampla</i> (Salisb.) DC.	2.2	2.3	1.3	2.2	1.2
<i>Potamogeton nodosus</i> Poir.	2.2	—	1.2	—	—
<i>Utricularia foliosa</i> L.	2.2	—	—	+2	+2
<i>Eleocharis interstincta</i> (Vahl.) R. y S.	—	1.1	—	1.1	—
<i>Sagittaria lancifolia</i> L.	—	—	+1	—	—
<i>Polygonum punctatum</i> Ell.	—	—	+1	—	—

Table 22
Nelumboneta luteae Samek et Moncada 1971

	1	2	3	4	5	6	7	8	9	10
Cover, %	80	50	85	70	85	80	90	85	100	95
<i>Nelumbo lutea</i> (Willd.) Pers.	4.4	3.3	1.3	1.2	4.4	3.4	4.5	4.4	4.4	3.3
<i>Eleocharis interstincta</i> (Vahl.) R. y S.	—	2.3	2.3	2.3	1.2	1.2	—	—	—	—
<i>Nymphoides aurea</i> (Britt.) Britt. et Millsp.	—	2.2	1.2	3.2	—	—	—	—	—	—
<i>Nymphaea ampla</i> (Salisb.) DC.	—	—	—	—	1.1	3.3	3.3	2.3	4.4	4.4
<i>Utricularia foliosa</i> L.	2.2	2.2	—	—	—	2.2	1.3	2.3	1.2	+2
<i>Panicum geminatum</i> Forsk.	—	—	3.3	1.2	—	+2	1.2	—	—	—
<i>Panicum parvifolium</i> Lam.	—	—	—	1.2	—	—	—	—	—	—
<i>Rhynchospora cyperoides</i> (Sw.) Mart.	—	—	—	1.1	—	—	—	—	—	—
<i>Schoenoplectus validus</i> (Vahl.) Koy.	—	—	—	—	—	1.1	2.2	1.2	1.1	1.2
<i>Utricularia mixta</i> Barnh.	—	—	—	—	—	—	+2	—	+2	—

water-lily mat. Five representative relevés were made by BORHIDI and DEL RISCO in the Zapata Swamp, E. of Buenaventura, Zanja de Jiqui, and by BORHIDI in the Laguna del Tesoro, October and November 1974 and March 1975, respectively. Type: Relevé No. 1 (Table 21).

2.2.2.4. *Nelumboneta luteae* Samek and Moncada 1971

The American lotus mat association formed by large leaved, highly emergent, rooted water plants is rather common in the littoral zones of both eutrophic and oligotrophic freshwater lakes. It is mostly a 2 or 3-layered

community, with a high emergent layer of *Nelumbo lutea*, a less emergent layer with floating leaves of *Nymphaea*, *Nuphar* and *Potamogeton* species and a submerged layer formed mostly by *Utricularia* species. Ten representative relevés can be divided into two subassociations. Relevés Nos 1–5 represent the subass. *eleocharetosum interstinctae* (relevés made by SAMEK and MONCADA at Sabanalamar, in oligotrophic lakes; type relevé: No. 1). Relevés Nos 6–10, made by BORHIDI and MUÑIZ in the Laguna Ariguanabo, January, 1970, represent the subass. *nymphaetosum amplae* of the more eutrophic waters (Table 22).

2.2.2.5. *Eichhornio heterospermae-Nymphoidetum aureae* Samek and Moncada 1971

This is an aquatic association of the slightly oligotrophic till eutrophic shallow lakes of W-Cuba, composed by rooted floating leaved aquatics (*Nymphoides*, *Marsilea*, *Nymphaea*) and of free floating aquatics (*Eichhornia*, *Salvinia*). Ten representative relevés were made in the Laguna Santa Lucia, near Mantua, at the edge of the white sand area of W-Cuba, by SAMEK y MONCADA. The relevés 1–5 represent the subass. *marsilietosum polycarpae*, those of Nos 6–7 represent the subass. typicum, and 8–10 the subass. *cabombetosum*. The characteristic species of the subassociation *marsilietosum* is correctly: *Marsilea polycarpa* Hook. et Grev. and not *M. quadrifolia* L. as it was published by the mentioned authors. Type: Relevé No. 6 (Table 23).

Table 23

Eichhornio heterospermae-Nymphoidetum aurei Samek et Moncada 1971

	<i>marsilietosum</i>					<i>cabombetosum</i>				
	1	2	3	4	5	6	7	8	9	10
Cover, %	95	45	75	80	90	80	40	100	60	80
<i>Nymphoides aureum</i> (Britt.) Britt. et Millsp.	4.4	2.2	3.3	3.4	4.4	4.4	2.3	1.2	1.1	2.3
<i>Eichhornia heterosperma</i> Alexander	+1	1.2	2.3	+1	1.2	1.1	1.2	5.5	2.2	+1
<i>Salvinia auriculata</i> Aubl.	+1	+1	+1	+1	1.3	+1	+1	—	+1	—
<i>Marsilea polycarpa</i> Hook. et Grev.	3.2	2.2	1.2	3.3	3.3	—	—	—	—	—
<i>Polygonum punctatum</i> Ell.	+1	+1	+2	+1	—	—	—	—	—	—
<i>Cabomba piauhyensis</i> Aubl.	—	—	—	+1	+1	—	—	2.3	3.3	2.3
<i>Nymphaea odorata</i> Dryand.	—	—	—	—	—	—	—	—	2.2	3.3
<i>Ludwigia inclinata</i> (L. f.) H. Hara	1.2	—	—	—	—	+1	—	—	+1	—
<i>Hymenachne amplexicaulis</i> (Rudge) Nees.	—	+1	+1	—	—	—	—	—	—	—

2.2.2.6. *Nymphoidetum aurei* Borhidi

Association monodominant formed by *Nymphoides aurea* in shallow slightly oligotrophic lakes of the white sand area. Type: Relevé No. 1 (Table 24) made by SAMEK and MONCADA in the Laguna Santa Lucia, other relevés (Nos 2–5) made by BORHIDI and OVIEDO in Laguna La Maquina, March, 1976.

2.2.2.7. *Nymphoidetum grayani* Borhidi

Freshwater plant association formed by rooted, floating leaved aquatics, in shallow, eutrophic waters of limestone carstic pits in South Isle of Pine and Peninsula of Guanahacabibes. The five representative relevés were made by BORHIDI, 26 December 1969, between Cayo Piedra and Punta del Este' Isla de Pinos. Type: Relevé No. 3 (Table 25).

2.2.2.8. *Polygonetum densiflori* Borhidi

Seasonally flooded freshwater plant community formed by aquatic and amphibic plants in the littoral zone of the shallow, muddy swamp lakes. It is

Table 24
Nymphoidetum aurei Borhidi

	1	2	3	4	5
Cover, %	100	80	65	70	90
<i>Nymphoides aurea</i> (Britt.) Britt. et Millsp.	5.5	4.5	3.4	4.4	4.5
<i>Nymphaea odorata</i> Dryand.	—	+1	2.2	+2	1.2
<i>Ludwigia inclinata</i> (L. f.) H. Hara	1.2	—	1.2	—	+2
<i>Ludwigia erecta</i> (L.) H. Hara	—	+1	—	+1	+1
<i>Hymenachne amplexicaulis</i> (Rudge) Nees.	1.2	—	—	—	+1
<i>Cabomba piahyensis</i> Aubl.	—	—	—	+1	1.2
<i>Caperonia palustris</i> (L.) St. Hil.	—	—	+1	—	—

Table 25
Nymphoidetum grayani Borhidi

	1	2	3	4	5
Cover, %	80	70	90	75	80
<i>Nymphoides grayana</i> (Griseb.) Arthur	4.5	4.4	5.5	4.4	4.5
<i>Cabomba piahyensis</i> Aubl.	+1	—	1.1	—	+2
<i>Nymphaea ampla</i> (Salisb.) DC.	+2	+1	—	—	—
<i>Hydrocotyle umbellata</i> L.	—	—	+1	—	1.1
<i>Marsilea polycarpa</i> Hook. et Grev.	1.2	+1	—	—	+1
<i>Salvinia natans</i> L.	—	+1	—	+1	—

Table 26
Polygonetum densiflori Borhidi

	1	2	3	4	5
Cover, %	80	95	100	100	90
<i>Polygonum densiflorum</i> Meisn.	3.3	4.5	5.5	4.4	4.4
<i>Eleocharis interstincta</i> (Vahl.) R. y S.	+1	—	1.2	1.1	—
<i>Sagittaria lancifolia</i> L.	1.1	—	—	—	—
<i>Hydrocotyle umbellata</i> L.	+1	1.2	2.2	2.2	—
<i>Nymphaea ampla</i> (Salisb.) DC.	—	+1	—	—	2.2
<i>Panicum geminatum</i> Forsk.	—	+1	—	—	1.1
<i>Ludwigia erecta</i> (L.) H. Hara	+1	—	+1	—	—
<i>Hymenachne amplexicaulis</i> (Rudge) Nees.	—	—	—	1.1	—

Table 27
Limnocharietum flavae Borhidi

	1	2	3	4	5
Cover, %	100	100	100	100	100
<i>Limnocharis flava</i> (L.) Buchen.	5.5	5.5	5.5	5.5	5.5
<i>Rhynchospora cyperoides</i> (Sw.) Mart.	1.1	+1	—	—	—
<i>Rhynchospora stellata</i> (Lam.) Griseb.	+1	—	1.2	1.1	1.2
<i>Fimbristylis ovata</i> (Burm. f.) Kern.	—	1.1	—	1.2	—
<i>Fuirena umbellata</i> Rottb.	+1	+1	1.1	1.1	+1
<i>Eleocharis cellulosa</i> Torrey	—	1.1	—	—	—
<i>Crinum americanum</i> L.	—	—	—	—	+2

a transitional community to the grass and sedge marshes. Five representative relevés made by BORHIDI in the Swamp area of Batabanó. Type: Relevé No. 3 (Table 26).

2.2.3. Alliance: **Crino-Limnocharion flavae** Borhidi 1979

Emergent aquatic vegetation of the slowly current, shallow, slightly eutrophic freshwaters, forming dense swards along the creek- and riversides.

Characteristic species: *Crinum americanum*, *C. oliganthum*, *Limnocharis flava*, *Fuirena umbellata*, *Rhynchospora* spp.

Associations studied in Cuba:

2.2.3.1. **Limnocharietum flavae** Borhidi

Association of swamp-lily formed in shallow, beds of slowly current freshwater streams, especially in river bends. Five representative relevés made

by BORHIDI in Rio Cristal, La Habana and Rancho Boyeros, October, 1969.
Type: Relevé No. 3 (Table 27).

3. Class: **CLADIETEA JAMAICENSIS** Knapp 1964

High reed-grass, sedge-, wintersedge-, cattail-marshes and swamps, rivercane- and bamboo-brakes in the regularly flooded alluvial surfaces and littoral zones of the lowland rivers in Central America and West Indies.

3.1. Order: **GYNERIO-BAMBUSETALIA** Borhidi 1979

Rivercane- and bamboo-brakes monodominant, formed by 3–10 m high, often lignified gramineas, along the riversides.

Characteristic species: *Gynerium sagittatum*, *Bambusa vulgaris* (naturalized), *Arundo donax*, etc.

3.1.1. Alliance: **G y n e r i o n s a g i t t a t i** Borhidi 1979

With the same characteristics as in the order. Association studied in Cuba:

3.1.1.1. **G y n e r i e t u m s a g i t t a t i** Borhidi

3.2. Order: **CYPERO HETEROPHYLLI-PENNISETETALIA** Borhidi 1979

Secondary, anthropically conditioned reedgrass- and sedge-marshes along the gravelly submontane and montane creeks and riversides.

Characteristic species: *Cyperus heterophyllus*, *C. surinamensis*, *Pennisetum purpureum*, etc.

3.2.1. Alliance: **C y p e r i o n h e t e r o p h y l l i** Borhidi 1979

With the same characters and in the order, represented with several anthropically conditioned, secondary associations in Cuba and the other Antilles.

3.3. Order: **SCIRPO-ELEOCHARIETALIA INTERSTINCTAE** Borhidi and Muñiz 1979

Big sized swamp and marsh vegetation formed by gramineas and cypereaceas in steady or seasonally flooded eutrophic, dystrophic or slightly saline wetland areas, without a continuous accumulation of peat in the soils.

Characteristic species; *Schoenoplectus validus*, *S. americanus*, *Eleocharis interstincta*, *E. cellulosa*, *E. articulata*, *Cyperus articulatus*, *C. diffusus*, *C. swartzii*, *Sagittaria lancifolia*, *S. intermedia*, *Echinodorus* spp., *Pontederia lanceolata*, *Paspalidium paludivagum*, *Panicum aquaticum*, *P. lacustre*, *Rhynchospora corniculata*, *R. gigantea*, etc.

3.3.1. **S a g i t t a r i o - E l e o c h a r i o n i n t e r s t i n c t a e** Borhidi and Del Risco 1979

High spike-rush and sedge marshes in eutrophic or slightly saline freshwaters of low wetlands. Characteristic species are the same as in the order.

Associations studied in Cuba:

3.3.1.1. *Sagittario-Eleocharietum interstinctae* Del Risco

Association of the littoral zone of the muddy eutrophical and peaty dystrophic lakes, ponds and bogs of the swamp- and wetland areas, formed by the dominant spike-rush species, sedges and with a layer of aquatic plants. Five representative relevés were by A. BORHIDI and O. MUÑIZ, in 1970 and later by E. DEL RISCO and A. BORHIDI (1974–1975), all in the Zapata Swamp. Type: Relevé No. 3 (Table 28).

3.3.1.2. *Paspalidietum paludivagi* Del Risco and Borhidi

Monodominant association of high, emergent gramineas forming a lower vegetation zone at the inner side of the reed-grass or cattail zone in the sublittoral belt of the eutrophic or dystrophic lakes. In typical form it is a one-layered community, but in deeper water develops a two-layered form, with a dense second herb layer formed by submerged aquatic plants. In our five relevés, all made by E. DEL RISCO and A. BORHIDI in the Zapata Swamp area (March, 1975), Nos 1–3 represent the two-layered subass. *vallisnerietosum*, and Nos 4–5 the subass. *typicum*. Type: Relevé No. 4 (Table 29).

Table 28
Sagittario-Eleocharietum interstinctae Del Risco

	1	2	3	4	5
Cover, %	100	100	90	90	100
<i>Eleocharis interstincta</i> (Vahl.) R. y S.	4.5	5.5	5.5	4.5	5.5
<i>Pontederia lanceolata</i> Nutt.	2.4	—	1.2	—	—
<i>Sagittaria lancifolia</i> L.	1.1	2.3	2.3	2.2	+2
<i>Nuphar luteum</i> ssp. <i>macrophyllum</i> (Small) Beal.	2.2	+r	—	—	—
<i>Nymphaea ampla</i> (Salisb.) DC.	—	+r	1.2	2.3	2.2
<i>Polygonum punctatum</i> Ell.	+r	—	—	1.1	—
<i>Typha domingensis</i> (Pers.) Kunth	—	1.1	—	—	—
<i>Cyperus ligularis</i> L.	—	1.1	+1	—	—
<i>Potamogeton nodosus</i> Poir.	—	+1	—	+1	1.1
<i>Proserpinaca palustris</i> L.	—	+1	+1	—	—
<i>Rhynchospora stellata</i> Griseb.	—	1.2	—	+1	—
<i>Hymenachne amplexicaulis</i> (Rudge) Nees	—	—	—	—	+1
<i>Phyla stoechadifolia</i> (L.) Small	—	+r	—	—	—
<i>Mikania hastata</i> (L.) Willd.	—	+r	—	—	—
<i>Scirpus cubensis</i> Poepp. y Kunth	2.3	—	1.2	+1	—

3.3.1.3. *Eleocharetum cellulosae* Borhidi

High spike-rush marsh association with two herb layers formed in the eutrophic wetlands and the dystrophic to slightly halotrophic seaside swamps

Table 29

Paspalidietum paludivagi Del Risco et Borhidi

	1	2	3	4	5
Cover, %	100	100	95	100	90
<i>Paspalidium paludivagum</i> (L.) Stapf	5.5	4.5	4.5	5.5	4.5
<i>Vallisneria neotropicalis</i> M. Vict.	5.5	2.3	2.2	—	—
<i>Gypha domingensis</i> (Pers.) Kunth.	+1	—	—	+1	—
<i>Hydrocotyle umbellata</i> L.	—	—	—	1.2	2.2
<i>Schoenoplectus validus</i> (Vahl) Koy.	—	—	1.1	—	1.2
<i>Proserpinaca palustris</i> L.	—	+1	—	—	—
<i>Panicum geminatum</i> Forsk.	—	—	+1	—	—
<i>Aeschynomene villosa</i> Poir. in Lam.	—	—	—	—	+1

Table 30

Eleocharetum cellulosae Borhidi

	1	2	3	4	5
Cover, %	100	95	100	90	100
<i>Eleocharis cellulosa</i> Torrey	5.5	4.4	5.5	3.4	4.4
<i>Sagittaria lancifolia</i> L.	+1	—	—	1.1	—
<i>Sporolobus virginicus</i> (L.) Kunth	+1	—	—	1.1	—
<i>Echinodorus berteroi</i> (Spreng) Fassett	—	+1	—	—	1.1
<i>Fimbristylis annua</i> (All.) R. y S.	2.2	1.2	2.2	1.2	2.2
<i>Fimbristylis spadiacea</i> (L.) Vahl.	—	2.2	—	1.2	1.2
<i>Rhynchospora stellata</i> Griseb.	2.2	1.1	2.2	+2	+2
<i>Rhynchospora corniculata</i> (Lam.) A. Gray.	—	+1	—	+2	—
<i>Vetiveria zizanoides</i> (L.) Nash	—	—	1.2	—	—
<i>Ludwigia suffruticosa</i> Maza	+1	+1	—	—	—
<i>Pontederia lanceolata</i> Nutt	+2	+2	+1	—	—
<i>Phyla stoechadifolia</i> (L.) Small	—	—	+1	+1	—
<i>Hydrocotyle verticillata</i> Thunb.	—	—	—	+2	1.1
<i>Cynodon dactylon</i> (L.) Pers.	—	—	1.2	2.2	2.2
<i>Ipomoea nil</i> (L.) Roth.	—	—	—	—	+1
<i>Ludwigia peruviana</i> (L.) H. Hara	—	—	—	+1	+2

Table 31
Cypereteum articulati Borhidi

	1	2	3	4	5
Cover, %	100	100	85	95	100
<i>Cyperus articulatus</i> L.	4.5	5.5	4.5	4.4	5.5
<i>Cyperus ligularis</i> L.	+1	1.1	+2	+1	+1
<i>Rhynchospora stellata</i> Griseb.	1.1	1.2	2.2	2.3	+1
<i>Limnocharis flava</i> (L.) Buchen.	+2	—	—	—	—
<i>Paspalum vaginatum</i> Sw.	—	—	1.1	1.1	—
<i>Cyperis filiformis</i> Sw.	—	+2	+1	—	1.2
<i>Eleocharis interstincta</i> (Vahl.) R. y S.	+2	—	—	1.1	—
<i>Aster exilis</i> Ell.	+1	1.1	2.2	1.2	—
<i>Pluchea purpurascens</i> (Sw.) DC.	—	—	+1	2.2	—
<i>Pluchea rosea</i> Godfr.	+1	1.1	—	—	—
<i>Ruellia paniculata</i> L.	—	+1	—	—	—
<i>Phyla stoechadifolia</i> (L.) Small	—	—	—	2.2	1.1
<i>Nephrolepis biserrata</i> (Sw.) Schott	1.1	—	1.1	—	—
<i>Bacopa monnieri</i> (L.) Pennell	—	2.4	—	2.3	2.3
<i>Nasturtium portoricense</i> Spreng.	2.2	—	2.3	1.3	—
<i>Ipomoea triloba</i> L.	—	+1	—	—	—
<i>Mikania hastata</i> (L.) Willd.	—	—	—	+1	—
<i>Commelina erecta</i> L.	+2	—	—	—	—

and marshes. The high herb layer is composed of the monodominant *Eleocharis cellulosa*, *Pontederia lanceolata*, *Sagittaria lancifolia* *Fimbristylis* spp., the lower one is formed by *Rhynchospora stellata*, *Cynodon*, *Hydrocotyle* and *Echinodorus* spp. Five representative relevés were made by BORHIDI in the marshes of Rancho Boyeros and the seaside swamps of Batabanó, October and December, 1969. Type: Relevé No. 1 (Table 30).

3.3.1.4. *Cyperetum articulati* Borhidi

A two-layered sedge marsh association on regularly flooded, muddy sites along slowly current swamp streams. The high herb layer is formed by the monodominant *Cyperus articulatus*, mixed with *Rhynchospora stellata*, *Eleocharis interstincta* and *Paspalum*, *Aster*, *Pluchea*, etc. species, the other herb layer is very low, formed by *Bulbostylis steacea*, *Phyla stoechadifolia*, *Bacopa monnieri* and *Nasturtium portoricense*. Five representative relevés were made by BORHIDI, at the northern edge of the Batabanó wetland, December, 1969. Type: Relevé No. 3 (Table 31).

3.3.1.5. *Schoenoplectetum validi* Borhidi and Muñiz

A high sedge marsh association in the littoral zone of the eutrophic and slightly dystrophic lakes and ponds, where it generally substitutes the lacking reed-grass- and cattail marshes. It has a seasonally flooded terrestrial form (Relevés Nos 1–5, Table 32) considered by me as subass. typicum, characterized by helophytes as *Centella erecta*, *Pontederia lanceolata*, *Bulbostylis* and *Fimbristylis* spp. (type: Relevé No. 3), and a permanently flooded aquatic form (Relevés Nos 6–10) considered by me as subass. *vallisnerietosum*, characterized by hydrophytes, as *Vallisneria* and *Utricularia* spp. (type: Relevé No. 9). Relevés (Table 33) made by BORHIDI and MUÑIZ, May, 1970 and by BORHIDI and DEL RISCO, March, 1975, in the Laguna del Tesoro, Zapata Swamp.

Table 32

Schoenoplectetum validi Borhidi et Muñiz

	1	2	3	4	5	6	7	8	9	10
Cover, %	60	65	80	70	55	100	100	100	100	100
<i>Schoenoplectus validus</i>	3.4	3.5	4.5	4.4	3.4	3.5	4.4	3.3	3.4	4.4
<i>Vallisneria neotropicalis</i> M. Vict.	—	—	—	—	—	5.5	3.5	4.5	5.5	3.4
<i>Utricularia foliosa</i> L.	—	+1	—	—	1.2	1.1	+1	1.2	+1	+2
<i>Nymphaea ampla</i> (Salisb.) DC.	+1	—	—	1.1	—	—	—	—	—	—
<i>Hydrocotyle umbellata</i> L.	+1	+1	—	—	—	1.1	+1	+2	1.1	1.1
<i>Centella erecta</i> (L. f.) Fern.	+1	1.1	1.1	+1	—	—	—	—	—	—
<i>Sagittaria lancifolia</i> L.	—	—	+1	—	+1	—	—	+1	—	—
<i>Echinodorus berteroi</i> (Spreng.) Fassett	+1	+1	—	—	—	—	—	—	—	—
<i>Pontederia lanceolata</i> Nutt.	+1	1.1	1.2	—	—	—	—	—	—	—
<i>Eleocharis interstincta</i> (Vahl.) R. y S.	1.1	—	—	1.2	2.2	—	—	—	—	—
<i>Rhynchospora corniculata</i> (Lam.) A. Gray	—	+1	+2	1.2	—	—	—	—	—	—
<i>Rhynchospora gigantea</i> Link.	+1	—	—	—	+1	—	—	—	—	—
<i>Bulbostylis capillaris</i> (L.) C. B. Clarke	—	+2	2.2	—	1.2	—	—	—	—	—
<i>Fimbristylis ovata</i> (Burm. f.) Kern	1.1	+1	1.2	1.2	2.2	—	—	—	—	—
<i>Fimbristylis castanea</i> (Michx.) Vahl.	1.1	1.2	1.1	2.2	+2	—	—	—	—	—
<i>Paspalidium paludivagum</i> (L.) Stapf	—	—	—	—	—	+2	—	—	1.1	—

Table 33

Acrostycho-Schoenoplectetum americanae Borhidi

	1	2	3	4	5
Cover, %	100	100	100	100	100
<i>Schoenoplectus americanus</i> Pers.	4.4	3.4	3.3	5.5	4.5
<i>Acrostichum aureum</i> L.	3.4	3.5	4.4	3.3	3.4
<i>Eleocharis cellulosa</i> Torrey	1.1	—	1.2	—	—
<i>Fimbristylis annua</i> (All.) R. y S.	—	1.1	—	+2	—
<i>Typha domingensis</i> (Pers.) Kunth.	—	—	1.1	—	+1
<i>Baccharis halimifolia</i> ssp. <i>angustior</i> DC.	+1	—	+1	+1	—
<i>Fimbristylis ovata</i> (Burm. f.) Kern.	—	+2	—	—	—
<i>Heliotropium curassavicum</i> L.	—	—	+1	—	—
<i>Conocarpus erecta</i> L.	—	—	—	+2	—
<i>Cladium jamaicense</i> Crantz	—	—	—	—	+1

Table 34

Rhynchosporo-Eleocharetum interstinctae Samek et Moncada 1971

	A	B	C
<i>Eleocharis interstincta</i> (Vahl.) R. y S.	V. +—4	V. +—3	V. 2—5
<i>Rhynchospora cyperoides</i> (Sw.) Mart.	V. +—2	V. +—2	V. 1—3
<i>Xyris grandiceps</i> Griseb. p. maj. p.	V. +—2	IV r—1	III. 1—2
<i>Utricularia foliosa</i> L.	III. +—2	V. +—2	III. 2—3
<i>Panicum parvifolium</i> Lam.	V. +—3	—	—
<i>Panicum tenerum</i> Beyr.	III. +—2	I. +	—
<i>Panicum lacustre</i> Hitchc. y Ekman	I. 2	I. +	—
<i>Scirpus confervoides</i> Poir.	—	V. 1—4	I. +
<i>Utricularia purpurea</i> Walt.	I. +	I. 1	—
<i>Blechnum serrulatum</i> A. Rich.	I. +	—	—
<i>Cyperonella palustris</i> (L.) St. Hil.	—	I. +	—
<i>Rhynchospora gigantea</i> Link	—	—	I. +

A: *panicetosum* (7 samples); B: *scirpetosum* (5 samples); C: *typicum* (5 samples)

3.3.1.6. *Acrostycho-Schoenoplectetum americanae* Borhidi

A halotrophic sedge marsh association of the seaside wetlands in the transitional zone of the eutrophic or dystrophic wetlands or swamps to the mangrove. The association is characterized by the co-dominant *Schoenoplectus*

americanus and *Acrostichum aureum*, accompanied by helophytes as *Typha* and *Cladium*, and by obligate and facultative halophytes as *Conocarpus erecta*, *Heliotropium curassavicum*, *Baccharis halimifolia* ssp. *angustior* and *Eleocharis cellulosa*. The five relevés were made by BORHIDI (December, 1969) near Batabanó. Type: Relevé No. 4 (Table 33).

3.3.2. Alliance: **Rhynchosporo-Eleocharion interstinctae** Samek and Moncada 1971

Sedge marsh vegetation of the littoral zone in the oligotrophic lakes of the white sand wetland of W-Cuba. It is characterized by acidophilous, little sized hydro- and helophytes, many of them endemics.

Table 35

Eleocharetum interstinctae Samek et Moncada 1971

	A	B	C
<i>Eleocharis interstincta</i> (Vahl.) R. y S.	V. 1—5	V. +—4	V. 2—3
<i>Paspalum serratum</i> Hitchc. y Chase	II. 1—3	I. +	— —
<i>Mayaca fluvialis</i> ssp. <i>wrightii</i> (Griseb.) Borhidi	I. 2—3	— —	— —
<i>Utricularia foliosa</i> L.	I. 3—4	II. +—2	II. 1
<i>Aeschynomene tuberculata</i> Griseb.	I. r—+	— —	I. 1
<i>Rhynchospora cyperoides</i> (Sw.) Mart.	I. +	I. +	I. +—1
<i>Sacciolepis striata</i> (L.) Nash.	I. r	— —	— —
<i>Vigna</i> sp.	I. 1	I. 1	— —
<i>Panicum lacustre</i> Hitchc. y Ekman	I. 1	— —	— —
<i>Scirpus confervoides</i> Poir.	I. +	III. 2—4	— —
<i>Nymphaea ampla</i> (Salisb.) DC.	I. r	V. 1—3	II. +—2
<i>Xyris grandiceps</i> Griseb.	I. 1	— —	— —
<i>Cyperus palustris</i> (L.) St. Hill	I. +	— —	— —
<i>Pontederia lanceolata</i> Nutt.	I. +	I. +	— —
<i>Brasenia schreberi</i> Gmel.	— —	II. +—3	— —
<i>Utricularia purpurea</i> Walt.	— —	I. 1—2	— —
<i>Panicum geminatum</i> Forsk.	— —	— —	V. +—4
<i>Nymphoides aureum</i> (Britt.) Britt. et Millsp.	— —	— —	II. +—3
<i>Fuirena scirpoidea</i> Michx.	— —	— —	I. 1
<i>Rhynchospora gigantea</i> Link.	— —	— —	I. +
<i>Ludwigia repens</i> Forst.	— —	— —	I. +
<i>Salvinia auriculata</i> Aubl.	— —	— —	I. +

B: *nymphaeetosum amplae* (13 samples); A: *typicum* (10 samples); C: *panicetosum geminati* (9 samples)

Characteristic species: *Eleocharis interstincta*, *E. alveolata*, *E. minutissima*, *E. oligantha*, *Xyris grandiceps*, *X. flexuosa*, *Rhynchospora gigantea*, *R. cyperoides*, *Panicum lacustre*, *P. parvifolium*, *P. tenerum*, *Mayaca wrightii*. The alliance has an intermediate position within the oligopsammose between *Mayacetalia fluviatilis* and *Rhynchosporo-Xyridetalia*.

Associations studied in Cuba:

3.3.2.1. *Rhynchosporo-Eleocharetum interstinctae* Samek and Moncada 1971

This association occupies the superior part of the littoral zone of the oligotrophic white sand lakes in the W-Cuba wetland. It can be divided into three subassociations, each representing a little belt in the zonation. The subass. *panicetosum parvifolii* occupies the exterior part, the subass. *scirpetosum confervoidis* the central part and the subass. *typicum* the transitional part to the inner side of the littoral zone (Table 34).

3.3.2.2. *Eleocharetum interstinctae* Samek and Moncada 1971

This sedge marsh association occurs in the same area in contact with the former one. It forms the inner ring of the littoral belt being divided into three subassociations. The subass. *nymphaetosum* is permanently flooded, the subass. *typicum* is seasonally flooded, generally in autumn, the subass. *panicetosum* forms the transitional zone to the former association (Table 35).

3.4. Order: TYPHETO-CLADIETALIA JAMAICENSIS Borhidi and Del Risco 1979

(Syn.: *Pontederio-Cladietalia* Knapp 1964 and *Rhynchosporo-Cladietalia* Knapp 1964 p.p.). Reed-grass and high sedge marshes and swamps generally on permanently flooded sites, with peat accumulation in the soils.

3.4.1. Alliance: *Typhion domingensis* Del Risco 1979

Reed-grass and cattail marshes, high sedge marshes and Maranthaceae-swamps in eutrophic or dystrophic wetlands on turfy soils.

Characteristic species: *Typha domingensis*, *Phragmites australis*, *Cladium jamaicense*, *Pontederia lanceolata*, *Fuirena umbellata*, *Cyperus giganteus*, *Thalia geniculata*, *Erianthus giganteus*, etc.

3.4.1.1. *Typhetum domingensis* Borhidi and Muñiz

Cattail marshes in eutrophic and dystrophic wetlands commonly as permanently flooded stands of the littoral zone, with a second herb layer formed by aquatic plants. Five representative relevés were made by BORHIDI and MUÑIZ May, 1970, and by BORHIDI and DEL RISCO March, 1975, in the Zapata Swamp area. Type: Relevé No. 3 (Table 36).

3.4.1.2. *Cyperetum gigantei* Borhidi

Giant sedge marsh association, up to 3 m high, with mostly three herb layers. The first herb layer is formed by the monodominant *Cyperus giganteus*,

Table 36
Typhetum domingensis Borhidi et Muñiz

	1	2	3	4	5
Cover, %	100	95	90	100	90
<i>Typha domingensis</i> (Pers.) Kunth	5.5	5.5	5.5	5.5	5.5
<i>Ipomoea triloba</i> L.	1.1	—	—	+1	—
<i>Mikania hastata</i> (L.) Willd.	1.1	1.1	1.1	+1	—
<i>Panicum virgatum</i> var. <i>cubense</i> Griseb.	—	1.1	1.2	+1	—
<i>Jussiaea suffruticosa</i> L.	+1	—	+1	—	1.2
<i>Polygonum punctatum</i> Ell.	+1	—	1.1	+1	+2
<i>Hymenachne donacifolia</i> (Raddi) Chase	+1	1.1	+1	+1	+1
<i>Solidago stricta</i> Ait.	—	+1	—	—	—
<i>Nymphaea blanda</i> GFW. Meyer	1.1	—	—	—	—
<i>Cabomba piauhyensis</i> Aubl.	2.2	+1	—	+2	—
<i>Hydrocotyle umbellata</i> L.	+1	1.2	+2	1.2	2.2
<i>Cynoctonum mitreola</i> (L.) Britt.	—	+1	1.2	—	—
<i>Pluchea purpurascens</i> (Sw.) DC.	—	+1	1.2	—	—
<i>Ipomoea tenuissima</i> Choisy	—	+1	+1	—	—
<i>Centella erecta</i> (L. f.) Fern.	—	—	+2	—	—
<i>Fuirena umbellata</i> Rottb.	—	—	+1	—	+1
<i>Aster exilis</i> Ell.	—	—	—	—	+1
<i>Fimbristylis ovata</i> (Burm. f.) Kern.	—	—	—	1.2	—

the second one by *Rhynchospora*, *Eleocharis* and Gramineae species, and the third one by aquatic and helophytic plants as *Limnocharis flava*, *Crinum americanum*, *Sagittaria*, and *Ruellia* spp. Five relevés were made by BORHIDI in the wet marshes of Rancho Boyeros, October, 1969 (Table 37). Type: Relevé No. 1.

3.4.1.3. *Polygoneto-Thalietum geniculatae* Borhidi

Seasonally flooded broadleaved marsh association, in which the Marantaceae *Thalia geniculata* is associated with high, helophytic gramineas as *Vetiveria zizanoides*, *Panicum virgatum* var. *cubense*, cyperaceas, and with *Polygonum portoricense*. There is developed also a species rich, densely closed low herb layer under the protection of the broadleaved *Thalia*. In the successional process this association is going over to a wet shrub savanna by settling of *Mimosa pigra*, *Paspalum secans* and others. Five relevés were made by BORHIDI in the wetland area of Rancho Boyeros, October, 1969. Type: Relevé No. 1 (Table 38).

Table 37
Cyperetum gigantei Borhidi

	1	2	3	4	5
Cover, %	90	85	95	100	100
<i>Cyperus giganteus</i> Vahl.	4.5	4.4	4.5	5.5	4.5
<i>Pontederia lanceolata</i> Nutt.	+1	+2	—	—	—
<i>Limnocharis flava</i> (L.) Buchen.	2.3	2.3	1.3	1.2	2.2
<i>Crinum americanum</i> L.	—	—	+2	—	+2
<i>Cyperus ligularis</i> L.	1.2	—	—	2.2	—
<i>Rhynchospora stellata</i> Griseb.	1.3	2.2	2.3	2.3	1.2
<i>Fuirena umbellata</i> Rottb.	+2	1.2	1.1	1.1	1.1
<i>Phyla nodiflora</i> (L.) Greene	1.2	2.2	2.2	+1	—
<i>Eleocharis interstincta</i> (Vahl.) R. y S.	—	—	—	+2	—
<i>Panicum lancearium</i> Trin.	+2	—	—	—	1.1
<i>Polygonum punctatum</i> Ell.	—	—	+1	—	—
<i>Rhynchospora cyperoides</i> (Sw.) Mart.	—	—	—	1.1	—
<i>Sagittaria lancifolia</i> L.	—	—	—	—	+1
<i>Panicum virgatum</i> var. <i>cubense</i> Griseb.	—	1.2	—	—	—
<i>Vetiveria zizanioides</i> (L.) Nash.	—	+1	1.1	—	—
<i>Hymenachne donacifolia</i> (Raddi) Chase	—	—	—	1.1	—
<i>Ruellia paniculata</i> L.	+1	—	—	—	—

3.4.2. Alliance: *Cladion jamaicensis* Borhidi and Muñiz 1979

High swamp vegetation of the winter sedge, mostly in dystrophic freshwaters and turfy soils, rarely forming wide extended swinging sedge-bogs on the surface of swamp-lakes.

Characteristic species: *Cladium jamaicense*, *Crinum americanum*, *C. oliganthum*, *Paspalum giganteum*, *Rhynchospora stellata*, *Panicum lancearium*, *P. condensum*, *P. virgatum*, *Andropogon glomeratus*, *Erianthus giganteus*, *Sacciolepis striata*, *Thelypteris palustris*, *Centella erecta*, *Solidago stricta*, etc.

Associations studied in Cuba:

3.4.2.1. *Crino-Cladietum jamaicensis* Borhidi and Muñiz

It is very common and widely distributed sedge-swamp association in the West Indies, represented with the greatest extension in the Zapata Swamp of Cuba and in the Everglades of Florida. The enclosed five relevés were made by BORHIDI and MUÑIZ May, 1970 and by BORHIDI and DEL RISCO March, 1975 in the Zapata Swamp. Type: Relevé No. 5 (Table 39).

Table 38
Polygoneto-Thalietum geniculatae Borhidi

	1	2	3	4	5
Cover, %	100	100	100	100	100
<i>Thalia geniculata</i> L.	5.5	4.5	5.5	4.5	4.5
<i>Vetiveria zizanoides</i> (L.) Nash.	1.2	2.2	1.2	2.3	2.2
<i>Panicum virgatum</i> var. <i>cubense</i> Griseb.	1.1	1.2	1.3	2.2	2.3
<i>Fuirena umbellata</i> Rottb.	+1	—	1.2	+2	—
<i>Pontederia lanceolata</i> Nutt.	+1	+2	—	—	—
<i>Typha domingensis</i> (Pers.) Kunth	+2	+1	—	+2	1.1
<i>Polygonum portoricense</i> Bert.	1.2	2.3	2.3	3.3	2.3
<i>Baccharis halimifolia</i> L.	+1	—	—	—	—
<i>Mimosa pigra</i> L.	—	1.1	—	2.1	—
<i>Sagittaria lancifolia</i> L.	1.2	+2	—	+2	—
<i>Rhynchospora stellata</i> Griseb.	—	—	—	—	1.2
<i>Nephrolepis biserrata</i> (Sw.) Schott	2.2	—	1.2	—	—
<i>Cyperus ligularis</i> L.	—	—	+1	+1	—
<i>Cyperus flavus</i> (Vahl.) Nees.	—	+1	—	+1	—
<i>Phyla nodiflora</i> (L.) Greene	2.3	2.3	—	+2	—
<i>Ludwigia repens</i> Forst.	—	—	1.2	—	—
<i>Centella erecta</i> (L. f.) Fern.	—	—	—	—	1.1
<i>Cynoctonum mitreola</i> (L.) Britt.	—	—	+1	—	1.2
<i>Hydrocotyle umbellata</i> L.	—	+2	—	+2	+2
<i>Cyperus filiformis</i> Sw.	—	—	1.2	—	—
<i>Bulbostylis capillaris</i> (L.) C. B. Clarke	—	—	—	+2	—
<i>Mikania hastata</i> (L.) Willd.	+2	1.1	—	—	—
<i>Ipomoea triloba</i> L.	—	+1	1.2	—	—
<i>Aster leonis</i> Britt.	—	—	—	+1	—
<i>Scleria pterota</i> Presl.	—	—	1.1	—	—
<i>Cassytha filiformis</i> L.	—	—	—	1.2	1.3

4. Class: **PARVIRHYNHOSPORO-ERIOCAULETEA** Borhidi 1979

Open and moderately closed short grassland vegetation on humid or at least seasonally wet, mostly oligotrophic acid soils, poor in nutrients, most frequently on humid white sand seasonally flooded by oligotrophic shallow freshwaters. The vegetation is formed by short or dwarf sized cyperaceas, xyridaceas, erioaulaceas, scrophulariaceas and rubiaceas with pygmaeous or creeping stems, accompanied by carnivorous plants as dwarf, rooted *Utricularia* species, *Pinguicula filifolia*, *Drosera intermedia* and little rosette hemi-

Table 39

Crino-Cladietum jamaicensis Borhidi et Muñiz

	1	2	3	4	5
Cover, %	90 + 30				
	100	100	100	100	100
<i>Cladium jamaicense</i> Crantz	5.5	4.4	4.5	4.4	5.5
<i>Andropogon glomeratus</i> (Walt.) BSP.	+ .1	+ .2	1.2	1.1	+ .2
<i>Typha domingensis</i> (Pers.) Kunth.	+ .r	3.2	+ .1	+ .r	—
<i>Ipomoea tenuissima</i> Choisy	+ .r	+ .1	—	—	—
<i>Cassytha filiformis</i> L.	+ .r	3.3	1.2	2.3	1.3
<i>Conocarpus erecta</i> L.	+ .r	+ .r	+ .r	—	+ .r
<i>Solidago stricta</i> Ait.	—	1.1	+ .2	—	1.1
<i>Annona glabra</i> L.	—	+ .r	—	+ .r	+ .r
<i>Hydrocotyle umbellata</i> L.	—	1.2	—	—	—
<i>Mikania hastata</i> (L.) Willd.	—	1.1	+ .1	+ .2	+ .1
<i>Cynoctonum mitreola</i> (L.) Britt.	+ .1	1.2	1.2	+ .2	1.2
<i>Panicum virgatum</i> var. <i>cubense</i> Griseb.	+ .2	1.1	1.1	1.2	1.2
<i>Echinochloa crusgalli</i> (L.) Beauv.	—	1.1	+ .2	—	—
<i>Rhynchospora cyperoides</i> (Sw.) Mart.	—	1.1	+ .1	+ .1	—
<i>Phyla nodiflora</i> (L.) Greene	—	1.1	—	—	—
<i>Sagittaria lancifolia</i> L.	—	+ .r	+ .1	+ .1	+ .1
<i>Pluchea purpurascens</i> (Sw.) DC.	—	+ .r	+ .1	—	1.2
<i>Sisyrinchium recurvatum</i> Blickeell	—	+ .r	—	—	—
<i>Baccharis halimifolia</i> L.	—	+ .r	—	—	—
<i>Chara foliosa</i> Meichle	—	3.3	—	—	—
<i>Bacopa monnieri</i> (L.) Pennell.	—	2.2	+ .2	—	—
<i>Crinum oliganthum</i> Urban.	—	(—)	+ .2	+ .1	+ .1
<i>Erionthus giganteus</i> (Walt.) Muhl.	—	—	+ .2	+ .2	—
<i>Panicum lancearium</i> Trin.	—	—	+ .1	+ .1	—
<i>Rhynchospora stellata</i> Griseb.	—	—	+ .2	+ .1	—
<i>Centella erecta</i> (L. f.) Fern.	—	—	1.1	1.2	1.2
<i>Sacciolepis striata</i> (L.) Nash.	—	—	1.1	+ .1	+ .1
<i>Thelypteris palustris</i> (L.) Salisb.	—	—	2.3	1.3	—
<i>Nymphaea ampla</i> (Salisb.) DC.	—	—	—	—	+ .1
<i>Nephrrolepis biserrata</i> (Sw.) Schott	—	—	—	—	+ .1
<i>Blechnum serrulatum</i> A. Rich.	—	+ .2	—	—	—
<i>Proserpinaca palustris</i> L.	—	—	—	—	+ .1
<i>Ludwigia natans</i> Ell.	—	—	1.2	—	—

cryptophytes as *Hyptis pedalipes*, *Aster grisebachii*, *Lachnorrhiza*, *Stenandrium*, *Sachsia*, etc.

4.1. Order: RHYNCHOSPORO-XYRIDETALIA Borhidi 1979

Short wet grassland vegetation on oligotrophic, mostly white sand soils.

Characteristic species: *Rhynchospora cyperoides*, *R. filifolia*, *R. podosperma*, *R. brachychaeta*, *R. tenuis*, *R. tracei*, *R. leptorhyncha*, *Acisanthera quadrata*, *Chaetolepis cubensis*, *Rhexia cubensis*, *Eleocharis capillacea*, *Herpyza grandiflora*, *Lachnocaulon ekmanii*, *Lachnanthes tinctoria*, *Panicum wrightianum*, *Scleria* spp., *Xyris bicarinata*, *X. navicularis*, *X. elliottii*, etc.

4.1.1. Alliance: **R h y n c h o s p o r o - X y r i d i o n** Borhidi 1979

Closed wet short grasslands very rich in endemics and plants of northern distribution pattern. Associations observed and studied in Cuba:

4.1.1.1. **Burmannie-Hypericetum fasciculati** Balatová-Tulačková and R. Capote 1983

4.1.1.2. **Chaetolepidi-Rhynchosporium filifoliae** Borhidi

4.2. Order: PAEPALANTHO-ERIOCAULETALIA Knapp 1964 emend. Borhidi 1979

Seasonally dry oligotrophic open short grasslands, formed by little sized rosette perennials, dwarf and needle-leaved shrubs, cushion-shaped plants, essentially on white sand, rarely on humid serpentine laterite, both extremely poor in nutrients.

Characteristic species: *Eriocaulon arenicola*, *E. fuliginosum*, *E. ovoideum*, etc., *Paepalanthus alsinoides*, *P. seslerioides*, *P. lamarckii*, *Syngonanthus androsaceus*, *S. insularis*, *S. lagopodioides*, *S. leonis*, *S. wilsonii*, *Xyris ekmanii*, *Scleria pauciflora*, *S. interrupta*, *S. ciliata*, *Richardia arenicola*, *R. ciliata*, *Nodocarpaea radicans*, *Borrchia strumpfioides*, *Mitracarpus depauperatus*, *Cuphaea pseudosilene*, *Cenchrus distichophyllus*, etc.

4.2.1. Alliance: **E r i o c a u l o - P a e p a l a n t h i o n** Borhidi 1979

With the same characteristics as in the order. Associations observed and studied in Cuba:

4.2.1.1. **Syngonantho-Paepalanthetum alsinoidis** Borhidi

4.2.1.2. **Spigelio sphagnicolae-Paepalanthetum seslerioidis** Bal.-Tul. and R. Capote 1983

5. Class: ZOSTERETEA Chapman 1974

Submarine rooted swards formed by submerged phanerogams of wide, mostly pantropical distribution.

5.1. Order: THALASSIO-SYRINGODIETALIA FILIFORMIS Knapp 1964

Tropical submarine submerged swards in the Caribbean region.

Characteristic species: *Thalassia testudinum*, *Syringodium filiforme*, *Halodule wrightii*, *H. beaudettii*, *Halophila baillonis*, *H. aschersonii*, *Limnobia laevigatum*.

5.1.1. Alliance: **Syringodio-Thalassion** Borhidi 1979

With the same characteristics as in the order. Associations observed and studied in Cuba:

5.1.1.1. **Syringodio-Thalassietum** (Ciferri 1936) Borhidi

Submarine phanerogamic swards of the shallow sublittoral zones of the sandy beach. Five representative relevés were made by BORHIDI in the Casilda Peninsula (Sancti Spiritus province) September, 1969, and in Punta Maisi (Baracoa province) March, 1970. Type: Relevé No. 2 (Table 40).

5.1.1.2. **Halodulo-Syringodietum filiformis** Borhidi

Association of the moderately to extremely saline waters of the estuaries of the rivers and the shallow mangrove-areas. Five representative relevés were made by BORHIDI and DEL RISCO March, 1975, and by BORHIDI February, 1981, in Las Salinas, Zapata Peninsula, Bahia de Cochinos. Type: Relevé No. 2 (Table 41).

5.1.1.3. **Limnobietum laevigati** Borhidi

(Syn.: *Hydromistrietum stoloniferae* Borhidi 1979 n.n.)

Open submarine sward formed mostly by stoloniferous phanerogams in shallow sublittoral zone of the sandy beaches. Five relevés were made by

Table 40

Syringodio-Thalassietum (Ciferri) Borhidi

	1	2	3	4	5
Cover, %	90	95	90	85	90
<i>Syringodium filiforme</i> Kütz.	2.3	1.3	3.3	3.4	3.4
<i>Thalassia testudinum</i> Banks et Sol. ex König	4.4	5.5	3.4	3.3	3.3
<i>Halodule wrightii</i> Aschers.	—	—	—	+ .2	—

Table 41

Halodulo-Syringodietum filiformis Borhidi

	1	2	3	4	5
Cover, %	90	80	65	80	95
<i>Syringodium filiforme</i> Kütz.	5.5	4.4	3.4	4.5	5.5
<i>Halodule beaudettii</i> d.Hart	—	+ .1	—	+ .1	+ .r
<i>Najas guadelupensis</i> (Spr.) Magnus	—	+ .1	2.2	—	—

BORHIDI in Jibacoa (November, 1969; May, 1974) Varadero (June, 1976) and Casilda (September, 1969). Type: Relevé No. 2 (Table 42).

6. Class: **IPOMOE0-MALLOT0NIETEA** Knapp 1964 emend. Borhidi 1979 (Syn.: *Ipomoeo-Tournefortietea* Knapp 1964 p.p.). Herbaceous and shrubby vegetation of the tropical sandy sea shores.

Table 42

Limnobiaetum laevigati Borhidi

	1	2	3	4	5
Cover, %	70	75	70	80	65
<i>Limnobiaetum laevigatum</i> (H. et B.) Mort.	4.4	4.4	3.4	4.5	4.4
<i>Halophila baillonis</i> Aschers.	+2	1.2	—	—	+1
<i>Halodule wrightii</i> Aschers.	—	+1	+1	+1	—
<i>Syringodium filiforme</i> Kütz.	—	—	2.2	1.2	—

Table 43

Sesuvio-Ipomoeetum pes-caprae Borhidi

	1	2	3	4	5
Cover, %	60	80	55	50	60
<i>Ipomoea pes-caprae</i> (L.) Sweet	3.3	4.4	3.4	3.3	3.3
<i>Canavalia maritima</i> (Aubl.) Thouars	+1	1.1	—	+1	1.1
<i>Cakile lanceolata</i> (Willd.) Schulz	+1	—	—	+1	—
<i>Cenchrus brownei</i> Roem. et Schult.	+1	—	1.1	—	—
<i>Sesuvium portulacastrum</i> L.	2.3	3.3	2.3	1.2	1.2
<i>Sporobolus virginicus</i> ssp. <i>littoralis</i> (Kunth) Borhidi	2.3	1.2	1.1	1.2	1.1
<i>Mallotonia graphaloides</i> (L.) Britt.	+1	—	—	+1	r.
<i>Ipomoea alba</i> L.	+1	—	+1	+r	+1
<i>Eclipta prostrata</i> (L.) L.	+r	—	—	—	+r
<i>Chamaesyce buxifolia</i> (Lam.) Small	+r	+1	—	+1	—
<i>Rhizophora mangle</i> L.	+r	—	—	—	—
<i>Laguncularia racemosa</i> (L.) Gaertn. f.	+r	—	—	—	—
<i>Stachytarpheta jamaicensis</i> (L.) Vahl	+r	—	+r	+1	—
<i>Ipomoea triloba</i> L.	+r	—	—	—	—
<i>Eragrostis salzmannii</i> Steud.	+2	—	—	—	—
<i>Diodia serrulata</i> (Beauv.) Tayl.	—	—	+1	1.1	—
<i>Stemodia maritima</i> L.	—	+1	—	—	1.1
<i>Philoxerus vermicularis</i> (L.) R. Br.	—	+1	+1	—	+1

- 6.1. Order: **CANAVALIO-IPOMOEETALIA** Knapp 1964 emend. Borhidi 1979
Open pioneering vegetation of the beaches formed by creeping lianes and
toloniferous streamers.

Characteristic species: *Canavalia maritima*, *Ipomoea pes-caprae*, *I. alba*, *Cakile mari-
tima*, *Cenchrus tribuloides*, *Diodia maritima*, *Philoxerus vermicularis*, *Sporobolus virginicus*,
Paspalum vaginatum, *Stemodia maritima*, etc.

- 6.1.1. Alliance: **Ipomoeo-Canavaliion maritimae** Borhidi 1979

With the same characteristics as in the order. Associations studied
in Cuba:

- 6.1.1.1. **Sesuvio-Ipomoeetum pes-caprae** Borhidi

Pioneer association of the sandy beaches. Originally it is a very common
plant community, but anthropically heavily damaged and destroyed in most
of the sandy shore areas. Five representative relevés were made by BORHIDI at
Alamar and Tarara near Habana, August, 1969. Type: Relevé No. 4 (Table 43).

- 6.1.1.2. **Philoxero-Unioletum virgatae** Borhidi

- 6.1.1.3. **Ipomoeo-Philoxeretum vermicularis** Ciferri n. nud.

- 6.2. Order: **BORRICHIO-MALLOTONIETALIA** Borhidi 1979

Closed littoral sandy meadows and low coastal scrubs on beach formed
by succulent leaved shrubs and suffrutescent plants.

Characteristic species: *Borrichia arborescens*, *B. cubana*, *Tournefortia-Mallotonia gna-
phaloides*, *Distichlis spicata*, *Ernodea littoralis*, *Suriana maritima*, *Scaevola plumieri*, *Erithalis
fruticosa*, *Spartina juncea*, *Uniola virgata*, *Casasia clusiifolia*.

- 6.2.1. Alliance: **Borrichio-Mallotonion** Borhidi 1979

Closed sandy meadows and seaside prairies in the sandy shore.

Associations studied in Cuba:

- 6.2.1.1. **Borrichio-Mallotonietum** Borhidi

Closed sandy sward or prairie association formed by stoloniferous grasses
and succulent leaved hemicryptophytes, suffitescents and low shrubs. It is a
widely distributed community but mostly heavily damaged and destroyed by
the anthropic use of the beaches for recreative purposes. Five representative
relevés were made by BORHIDI at Alamar, Tarara and Guanabo East of
Habana, August–October, 1969. Type: Relevé No. 3 at Alamar (Table 44).

Other observed communities:

- 6.2.1.2. **Sporobolo-Spartinetum junceae** Ciferri 1936

- 6.2.1.3. **Turnereto-Unioletum virgatae** Ciferri 1936

- 6.2.2. Alliance: **Suriano-Baccharidion halimifoliae** Bor-
hidi 1979

Table 44
Borrichio-Mallotonietum Borhidi

	1	2	3	4	5
Cover, %	85	80	90	80	85
<i>Borrichia arborescens</i> (L.) DC.	3.3	1.3	3.3	2.2	1.2
<i>Mallontonia gnaphaloides</i> (L.) Britt.	1.1	2.2	1.3	2.2	2.3
<i>Ernodea littoralis</i> Sw.	1.2	1.1	+1	—	+2
<i>Uniola virgata</i> (Poir.) Griseb.	1.3	2.3	1.1	1.2	—
<i>Sporobolus virginicus</i> ssp. <i>littoralis</i> (Kunth.) Borhidi	1.1	2.2	2.2	1.2	1.2
<i>Turnera ulmifolia</i> L.	+1	—	—	+r	—
<i>Pectis cubensis</i> (A. Rich.) Griseb.	—	+r	—	—	—
<i>Distichlis spicata</i> (L.) Greene	+2	1.2	2.3	1.2	3.3
<i>Chamaesyce hyssopifolia</i> (L.) Small	—	+1	+1	—	—
<i>Erithalis fruticosa</i> L.	—	—	—	+1	+1
<i>Cenchrus brownei</i> Roem. et Schult.	—	—	+1	+1	—
<i>Canavalia maritima</i> (Aubl.) Thouars	+1	—	—	—	+1
<i>Stemodia maritima</i> L.	—	+1	—	—	—
<i>Stachytarpheta jamaicensis</i> (L.) Vahl	—	—	+1	—	—
<i>Chamaesyce brasiliensis</i> (Lam.) Small	—	—	+1	—	—
<i>Suriana maritima</i> L.	—	—	—	+1	+1

Littoral thickets in the transition of the littoral meadows towards the *Coccoloba*-scrub.

Associations observed and studied in Cuba:

6.2.2.1. *Ernodeo-Surianetum maritimae* Ciferri 1936

6.2.2.2. *Suriano-Baccharidetum halimifoliae* Borhidi

The *Suriana-Baccharis* thicket is rather common in the seaward slopes of the coastal dunes, forming mostly a thin skirt along the edge of the *Coccoloba*-scrub. It develops in greater extension and with a more species rich variant on the flat beaches anthropically not influenced, and on the edge of the coastal lagoons. Five representative relevés were made at Punta del Este, Punta Gorda, Carapachibey, all in the South part of Isla de Pinos. Type: Relevé No. 3 (Table 45), Carapachibey, December, 1969. A. BORHIDI.

7. Class: *SESUVIO-RHACHICALLIETEA* Borhidi 1979

Orophilous halophytic vegetation of the supratidal rocky shores, conditioned by the influence of salt spray, the unprotected exposure and the

extremely poor soil conditions. In the hard limestone coastal areas it can extend inland to a 100–200 m wide range.

7.1. Order: TRIANTHEMO-SESUVIETALIA Borhidi 1979

Pioneer rock vegetation on the coastal cliffs and supratidal rock pavements, formed mostly by creeping, leaf-succulent plants, under a continuous influence of the tidal spray.

Characteristic species: *Sesuvium portulacastrum*, *S. maritimum*, *Trianthema portulacastrum*, *Lithophila muscoides*, etc.

7.1.1. Alliance: **Trianthemo - Sesuvion** Borhidi 1979

Open, species poor coastal rock pavement vegetation, formed mostly by prostrate, leaf-succulent plants.

Table 45

Suriano-Baccharidetum halimifoliae Borhidi

	1	2	3	4	5
Cover, %	75	85	100	95	85
<i>Suriana maritima</i> L.	3.3	3.3	3.4	4.5	4.5
<i>Baccharis halimifolia</i> L.	2.3	3.3	2.3	1.1	+1
<i>Borrchia arborescens</i> (L.) DC.	+1	+1	1.2	1.2	+1
<i>Uniola paniculata</i> L.	2.2	1.2	2.3	1.1	+1
<i>Ernodea littoralis</i> Sw.	—	—	1.2	+1	2.2
<i>Erithalis fruticosa</i> L.	+1	—	1.1	—	+1
<i>Mallotonia gnaphaloides</i> (L.) Britt.	—	+1	1.1	—	+1
<i>Sporobolus virginicus</i> ssp. <i>littoralis</i> (Kunth.) Borhidi	1.2	1.2	—	2.3	+1
<i>Turnera ulmifolia</i> L.	—	—	+r	+1	—
<i>Fimbristylis spathacea</i> Roth	1.2	1.1	—	—	—
<i>Torulinium filiforme</i> (Sw.) Clarke	—	—	—	+2	—
<i>Distichlis spicata</i> (L.) Greene	—	—	1.2	+2	1.2
<i>Batis maritima</i> L.	+2	+2	—	—	—
<i>Chamaesyce hyssopifolia</i> (L.) Small	—	—	+1	—	+1
<i>Cassia lineata</i> Sw.	—	—	—	+2	—
<i>Flaveria trinervia</i> (Spr.) Mohr	+1	—	—	—	+2
<i>Eclipta prostrata</i> (L.) L.	—	+r	—	+r	—
<i>Ipomoea triloba</i> L.	—	+r	+r	—	—
<i>Paspalum fimbriatum</i> HBK.	—	+2	—	—	—
<i>Dactyloctenium aegyptium</i> (L.) Richt.	—	—	+1	—	—
<i>Sesuvium portulacastrum</i> L.	—	—	—	—	+2
<i>Cynodon dactylon</i> (L.) Pers.	—	—	—	+2	—

Table 46*Lithophilo-Trianthemetum portulacastris* Borhidi

	1	2	3	4	5
Cover, %	25	35	30	40	20
<i>Lithophila muscoides</i> Sw.	1.2	2.3	1.2	2.2	1.2
<i>Trianthema portulacastrum</i> L.	2.2	2.2	2.3	3.4	2.3
<i>Rhachicallis americana</i> (Jacq.) Hitchc.	+.r	—	—	+.1	—
<i>Conocarpus erecta</i> L.	—	+.1	—	—	—
<i>Sesuvium portulacastrum</i> L.	—	+.1	+.1	+.r	—

Table 47*Trianthemo-Sesuvietum portulacastris* Borhidi

	1	2	3	4	5
Cover, %	45	55	50	60	40
<i>Sesuvium portulacastrum</i> L.	3.3	3.4	3.3	4.4	2.3
<i>Trianthema portulacastrum</i> L.	1.2	1.3	2.2	1.2	2.2
<i>Rhachicallis americana</i> (Jacq.) Hitchc.	—	+.1	+.1	—	—
<i>Conocarpus erecta</i> L.	—	—	—	+.2	—
<i>Heliotropium humifusum</i> HBK.	—	—	—	+.1	—
<i>Chamaesyce buxifolia</i> (Lam.) Small	—	+.r	—	—	—
<i>Lithophila muscoides</i> Sw.	—	—	—	—	+.1
<i>Flaveria linearis</i> Lag.	—	—	+.r	—	—

Associations studied in Cuba:

7.1.1.1. *Lithophilo-Trianthemetum portulacastris* Borhidi

Open prostrate vegetation formed in the most seaward range of the rocky shore zonation, by *Lithophila muscoides* and *Trianthema portulacastrum*. Five representative relevés were made by BORHIDI at Jibacoa (October, 1969), at Alamar (August, 1969) and at Punta Colorados (Cienfuegos province) September, 1969. Type: Relevé No. 2 at Jibacoa (Table 46).

7.1.1.2. *Trianthemo-Sesuvietum portulacastris* Borhidi

Somewhat closer prostrate vegetation on the landward range of the pioneering zone of the rocky shore zonation (petrohalophytia) formed by *Sesuvium portulacastrum* and *Trianthema portulacastrum* and a few companion littoral halophytes. Five relevés were made by BORHIDI at the same places as by the former association. Type: Relevé No. 4 at Jibacoa (Table 47).

7.2. Order: BORRICHIO-RHACHICALLIETALIA Borhidi 1979

Moderately closed vegetation of the rocky shores formed mostly by cushion-shaped hemicryptophytes and chamaephytes, and dominantly by succulent-leaved dwarf shrubs and shrubs. This plant community group is distributed all over the Caribbean shores.

Table 48
Conocarpus-Rhachicallietum americanae Borhidi

	1	2	3	4	5
Cover, %	45	45	60	70	80
<i>Rhachicallis americana</i> (Jacq.) Hitchc.	3.3	2.3	3.4	3.3	1.2
<i>Conocarpus erecta</i> L. f. <i>caespitosa</i>	1.2	2.2	1.2	3.4	4.4
<i>Chamaesyce buxifolia</i> (Lam.) Small.	+2	+1	+1	—	—
<i>Chamaesyce adenoptera</i> (Bertol.) Millsp.	+r	—	+1	—	—
<i>Pectis leptcephala</i> (Cass.) Urb.	—	+1	+1	—	—
<i>Heliotropium humifusum</i> HBK.	1.1	+1	+1	+2	+r
<i>Cassia lineata</i> Sw.	—	+1	—	—	—
<i>Melochia tomentosa</i> L.	+1	—	—	—	—
<i>Flaveria linearis</i> Lag.	—	+1	1.1	—	—
<i>Tephrosia senna</i> HBK.	+r	+1	—	—	—
<i>Coccoloba uvifera</i> L.	+1	—	—	—	—
<i>Suriana maritima</i> L.	+1	+1	—	+1	—
<i>Opuntia dillenii</i> Ker.-Gawl.	1.1	1.1	—	—	1.1
<i>Turnera ulmifolia</i> L.	+1	+1	—	+1	—
<i>Stachytarpheta jamaicensis</i> (L.) Vahl.	+r	—	+r	—	—
<i>Chenopodium ambrosioides</i> L.	+r	—	—	—	—
<i>Cassia clarensis</i> (Britt.) Howard	+1	—	—	—	—
<i>Pectis rutilandi</i> Howard et Briggs	+r	—	—	—	—
<i>Morinda royoc</i> L.	+1	—	1.1	1.2	—
<i>Chamaesyce hirta</i> (L.) Millsp.	—	—	+r	+1	—
<i>Canavalia maritima</i> (Aubl.) Thouars	—	—	+1	+1	+1
<i>Solanum bahamense</i> L.	—	+1	—	—	—
<i>Borrichia arborescens</i> (L.) DC.	—	+1	+1	+2	+1
<i>Sesuvium portulacastrum</i> L.	+2	+2	+1	1.2	1.2
<i>Mallotonia gnaphaloides</i> (L.) Britt.	+2	+1	—	—	—
<i>Catesbaea parviflora</i> Sw.	—	—	—	—	+1
<i>Castela calcicola</i> (Britt. et Small) Ekm. et Urb.	—	—	+1	—	1.2
<i>Jacquemontia jamaicensis</i> (Jacq.) Nall. f.	—	—	+2	—	1.2
<i>Ipomoea pes-caprae</i> (L.) Sweet	—	—	—	—	+2

Characteristic species: *Rhachicallis americana*, *Borrichia arborescens*, *B. cubana*, *Conocarpus erecta* f. *caespitosa*, *Heliotropium humifusum*, *Chamaesyce buxifolia*, *Pectis* spp., *Strumpfia maritima*, *Erithalis vacciniifolia*, *Flaveria linearis*, *Opuntia dillenii*, etc.

7.2.1. Alliance: **Borrichio-Rhachicallion** Borhidi 1979

With the same characteristics as in the order. Associations observed and studied in Cuba:

7.2.1.1. **Sesuvio-Rhachicallietum americanae** Borhidi

7.2.1.2. **Conocarpus-Rhachicallietum americanae** Borhidi

Association of the high, seaside, intensively eroded limestone banks, a humid, saline dog-tooth site. The prostrate form of the *Conocarpus erecta* can form a continuous closed carpet together with *Rhachicallis*, *Catesbaea*, *Castela*, *Opuntia* intertwined by xerophytic lianes as *Morinda royoc*, *Jacquemontia jamaicensis* and *Ipomoea*. Five representative relevés were made by BORHIDI at Punta Colorados, September, 1969, at Mal Paso, May, 1970 and at Punta del Holandés (Peninsula of Guanahacabibes), December, 1974. Type: Relevé No. 3 at Mal Paso (East of Playa Girón) (Table 48).

7.2.1.3. **Borrichio-Rhachicallietum americanae** (Uphof 1924) Ciferri 1936

7.2.1.4. **Erithali-Strumpfietum** Borhidi

It is an endemic littoral dwarf shrub association of the southern seaside limestone cliffs in South Oriente and Hispaniola, mostly distributed along the coastal belt between Siboney and Maisí. The association is formed by two

Table 49
Erithali-Strumpfietum Borhidi

	1	2	3	4	5
Cover, %	60	70	40	50	70
<i>Erithalis vacciniifolia</i> (Griseb.) Wr.	3.4	4.4	3.3	2.3	3.3
<i>Strumpfia maritima</i> Jacq.	2.3	2.3	1.2	3.3	3.4
<i>Conocarpus erecta</i> L. f. <i>caespitosa</i>	—	—	+1	+1	—
<i>Rhachicallis americana</i> (Jacq.) Hitchc.	—	1.1	—	—	+1
<i>Sesuvium portulacastrum</i> L.	—	—	+1	—	—
<i>Trianthema portulacastrum</i> L.	+1	—	—	—	—
<i>Lithophila muscoides</i> Sw.	+1	—	—	—	—
* <i>Caribaea littoralis</i> Alain	—	—	—	—	+2
<i>Caesalpinia pauciflora</i> (Griseb.) Wr.	—	—	—	+r	—

* Endemic species

co-dominant succulent leaved dwarf shrubs, the subendemic *Erithalis vacciniifolia* and the West Indian *Strumpfia maritima*. A notable companion is the endemic Cuban littoral cushion-plant: *Caribaea littoralis*. Five relevés were made by BORHIDI at Siboney and Macambo (near to San Antonio del Sur) January and February, 1976. Type: Relevé No. 1 E. of Playa Siboney (Table 49).

8. Class: **BATIDI-SALICORNIETEA** Knapp 1964

Vegetation of the salines formed by leaf-succulent dwarf shrubs and annual or perennial succulents and by grasses of high osmotic tension. The belt of the saline vegetation is developed inlandwards behind the mangrove-zone, in the area flooded only twice a year by the high equinoctial tides, where the salt trends to concentrate extremely by evaporation, and allows the development of herbaceous flats with *Salicornia* mats and/or low *Batis maritima* scrub.

8.1. Order: **BATIDI-SALICORNIETALIA AMBIGUAE** Knapp 1964

Tropical vegetation of saline sites formed mostly by succulent plants.

Characteristic species: *Batis maritima*, *Salicornia ambigua*, *S. perennis*, *Suaeda fruticosa*, *S. linearis*, *Fimbristylis spathacea*, etc.

8.1.1. Alliance: **Fimbristyli-Salicornion perennis** Chapman 1960

Open vegetation of saline sites formed by suffrutescent plants.

Associations studied in Cuba:

8.1.1.1. **Fimbristyli-Salicornietum perennis** Borhidi

Association of saline vegetation developed on humid, seasonally flooded shallow sandy seaside sites. Five representative relevés were made by BORHIDI at the Guanahacabibes Peninsula and the Southern shore of the Pinar del

Table 50

Fimbristyli-Salicornietum perennis Borhidi

	1	2	3	4	5
Cover, %	35	40	40	50	45
<i>Salicornia perennis</i> Mill.	2.3	2.3	3.3	3.3	1.2
<i>Fimbristylis spathacea</i> Roth	2.2	1.2	1.2	2.2	2.3
<i>Distichlis spicata</i> (L.) Greene	—	1.2	—	+2	—
<i>Heliotropium curassavicum</i> L.	+1	—	+1	—	—
<i>Batis maritima</i> L.	—	—	—	+2	1.2
<i>Suaeda linearis</i> Moq.	+1	—	—	—	—
<i>Nostoc commune</i> L.	—	—	—	—	+2

Table 51
Salicornio-Distichlietum spicati Borhidi

	1	2
Cover, %	85	90
<i>Distichlis spicata</i> (L.) Greene	5.5	5.5
<i>Heliotropium curassavicum</i> L.	+r	+1
<i>Salicornia perennis</i> Mill.	1.1	1.2
<i>Fimbristylis annua</i> L.	+r	+1
<i>Fimbristylis spathacea</i> Roth	—	+2
<i>Conocarpus erecta</i> L. f. <i>prostrata</i>	1.2	—
<i>Portulaca oleracea</i> L.	+r	—

Rio province at La Coloma, March, 1976. Type: Relevé No. 1 at El Veral (Table 50).

8.1.2. Alliance: **Batidion maritimae** Borhidi 1979

Closed vegetation of the saline belt, formed mostly by succulent suffrutescent plants.

Association studied in Cuba:

8.1.2.1. **Batidetum maritimae** Ciferri 1936

8.2. Order: **DISTICHLIO-SPARTINETALIA** (Chapman 1974) Borhidi and Del Risco 1979

Saline prairie vegetation of the supratidal belt formed by grasses and sedges of high osmotic tension.

Characteristic species: *Distichlis spicata*, *Spartina juncea*, *Sporobolus virginicus* ssp. *littoralis*, *Chloris sagraeana*, *Eragrostis salzmannii*, *Philoxerus vermicularis*, *Heliotropium curassavicum*, etc.

8.2.1. Alliance: **Distichlion spicatae** (Chapman 1960) Borhidi and Del Risco 1979

With the same characteristics as in the order. Association studied in Cuba:

8.2.1.1. **Salicornio—Distichlietum spicati** Borhidi

Species poor, monodominant saline prairie in the higher flat terrains of the mangrove belt. Type relevé (No. 1.) made by Borhidi and Del Risco, March, 1975, in Las Salinas, Peninsula de Zapata. (Table 51.)

REFERENCES

- Borhidi, A., Muñiz, O., Del Risco, E. 1979: Clasificación fitocenológica de la vegetación de Cuba. *Acta Bot. Acad. Sci. Hung.* **25**: 263–301. and the literature cited in it.

THE LOCAL COMPLEX OF PHYTOCENOSES AND THE VEGETATION LANDSCAPE — FUNDAMENTAL UNITS OF THE SPATIAL ORGANIZATION OF THE VEGETATION ABOVE THE PHYTOCENOSE LEVEL

J. SOLON

INSTITUTE OF GEOGRAPHY AND SPATIAL ORGANIZATION, POLISH ACADEMY OF SCIENCES,
WARSAW, POLAND

(Received: 1 December 1982)

This paper proposes a system of units useful for descriptions of a pattern in a distribution of plant communities.

The basic unit of the spatial organization above the phytocenose level is a local complex of phytocenoses. It comprises all plant communities living together in the very same, homogeneous site (habitat), being under the same kind of human influences.

The next unit of the system is a vegetation landscape. The vegetation landscape is characterized by more or less regularly distributed habitats of different types of the potential natural vegetation, occupied by exactly defined local complexes of phytocenoses.

Moreover, the author discusses two other spatial categories, i.e. the group of dependent communities and the vegetation catena; both are only supplementary units, putting in order spatial distribution.

Introduction

A great number of investigations show, without any doubt, that the plant cover is not simply a mixture of plant associations, but — due to a variable relief combined with different soils and a moisture content — there is a special kind of pattern in the distribution of phytocenoses.

The organized spatial structure of the vegetation was noticed as long ago as in the last century. In 1858 LORENZ described peat-bogs in the surroundings of Salzburg as association complexes. In 1863 KERNER's work was published, in which the Hungarian "puszta" was treated as a main formation with spots of other associations, regularly scattered in space.

Since then many articles have dealt with spatial vegetation units of different kinds and sizes. The aim of the majority of these investigations was to establish a system of spatial units and/or to apply the system to solve the given problem for the given area.

Despite all the differences resulting from the diversity of the various authors' theoretical and practical approaches, all units and systems could be put into one of the three groups corresponding to the three levels of the biosphere organization, i.e. planetary, regional and local (NEEF 1967).

In the first group of systems the whole surface of the Earth is divided into vegetation landscapes according to different climatic zones (PASSARGE 1919, GRANÖ 1929, BERG 1958).

Into the second group might be put all the units referring to the distribution of the vegetation at regional level. By this approach the plant cover diversity is described and

explained in connection with edaphic and moisture conditions. The main concept serving as the basis for this kind of investigations is the theory of the potential natural vegetation (TÜXEN 1956, SCHMITHÜSEN 1968, BEGUIN, HEGG 1975, 1976, MATUSZKIEWICZ 1979, PLIT 1981) or other theories of a similar character (RATSKOVSKAYA 1963, ISATCHENKO 1966, ILINA 1975).

Contrary to the two above-mentioned groups, landscape vegetation units of the third group are referred to small areas at local level. In these cases the main criteria of vegetation differentiation include microenvironmental factors and/or human impacts.

It is surprising that, despite many different units proposed — e.g. the vegetation complex (TÜXEN 1973), the complex of communities (DOING 1979), the spatial association complex (MEDWECKA-KORNAŚ 1978), microcombinations (ISATCHENKO 1966), the local aggregation of phytocenoses (MATUSZKIEWICZ 1979), the vegetation mosaic (SCHLÜTER 1979, 1980), etc. — there is no general method for delimiting units of this kind.

Moreover, the size and contents of these units are based on a the author's subjective view rather than on the real vegetation pattern in the space. That is why, in most cases, it is impossible to compare the proposed units with each other. The hierarchic character of vegetation units is not taken into consideration either.

The aim of the study

The aim of this study is to present a hierarchic system of units useful for the detailed description of the spatial distribution of real vegetation in small areas.

This proposition arose from the analysis of other systems' faults and advantages as well as from the many years field investigations in the surroundings of the town Suwalki (NE Poland).

General remarks

The system of vegetation spatial units ought to have the following proprieties:

- reflection of the hierarchic structure of a vegetation;
- embracement of natural, spatial-functional, ecological complexes;
- the possibility to delimit both real and typological units;
- the possibility to use these units not only for the formal description of the vegetation but also for vegetation mapping and regionalization;
- comparability, in rank and size, with units of the complex physical-geographical typology and regionalization.

The system presented here is based on the hypothesis of the existence of at least two main spatial units of the vegetation above the phytocenose level, i.e. the local complex of phytocenoses and the vegetation landscape, as well as two other spatial categories, i.e. the group of dependent communities and the vegetation catena (Fig. 1).

It seems that, contrary to the previous systems, this one fulfills all the above conditions.

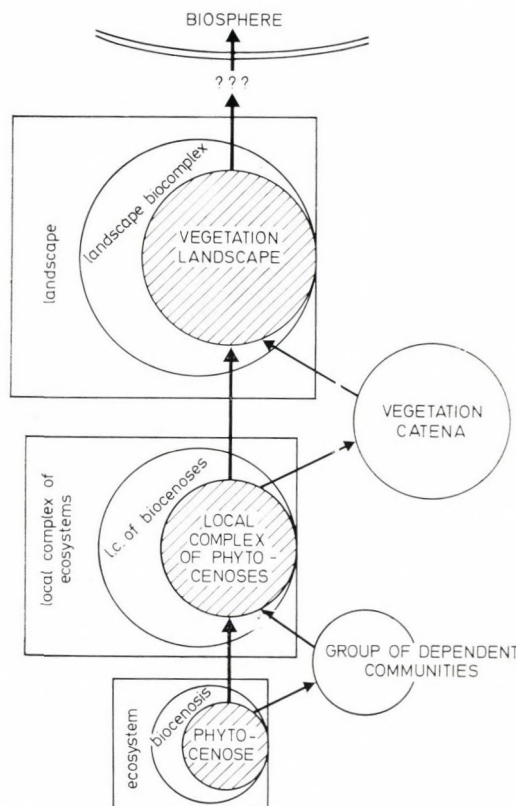


Fig. 1. Spatial units of vegetation and their hierarchy

The local complex of phytocenoses

The local complex of phytocenoses is the first spatial unit of a vegetation above the phytocenose level. It comprises all plant communities living together on the same homogeneous habitat under the same human influences.

There are two reasons for the habitat homogeneity postulate. The first arose from the opinion, that — at least in most cases — connections between plant communities growing together on the same site are stronger than connections between adjacent ones living on different habitats. These connections are not only due to the matter, energy and information flow, but also, which seems to be more important, to the identical kind of the succession of, and common reactions to environmental changes of all kinds.

Moreover, it happens that year by year there are changes in the area and location of individual phytocenoses, but the general pattern of distribution (register of plant communities, area fragmentation, quantitative proportions of associations, form of a neighborhood, etc.) is stable for several years.

The second reason is to eliminate or, at least, to restrict the arbitrariness of delimiting units, as it is in cases of those based on habitat mosaics (MEDVECKA-KORNAŠ 1978, DOING 1979, SCHLÜTER 1979), showing only the individual, and being impossible to compare and typologize.

In the system proposed here the analysis and comparison of individual, real local complexes of phytocenoses makes it possible to define their types. It seems that the best way for a formal description of these types is to use the method elaborated for sigmassociations (BEGUIN, HEGG 1975, 1976, BALCERKIEWICZ, WOJTERSKA 1978 and others).

The complete description of the character of the type of the local complex of phytocenoses contains:

- the register of all plant associations;
- the distinction between principal and supplementary associations as well as between specific, non-specific and alien ones;
- the quantitative proportions of associations;
- the mode of the associations' distribution (i.e. areal, linear or as a point);
- the value of the area fragmentation index;
- the mean percentage of borders between each pair of associations with respect to the mean number of all borders inside the local complex of phytocenoses;
- the type of the potential plant association.

Some terms mentioned above ought to be explained. The principal associations are those which occupy more than 10% of all the area. In any given type of the local complex of phytocenoses there are 2–5 associations of this kind. Other associations occurring are supplementary ones.

The specific associations can be met in one type (or a group of types) only. The non-specific ones occur in very different types; they have a very low fidelity.

Sometimes it happens that, under special circumstances, in degraded places, one can meet plant communities belonging to a type quite different from the local complex of phytocenoses. This is an alien association.

Beside well developed communities, inside the local complex of phytocenoses one may find fragments of communities, dependent communities, and even synusia or separate populations (e.g. the population of trees growing on roadsides). All these cenotaxa enrich the character of local complexes of phytocenoses, often determining their mutability.

At the local level the register of plant associations of the separate local complex of phytocenoses is mainly determined by the quality of the habitat and a type of land use, and only in a small degree by the geographical variety of a plant cover. These factors also determine the size of local complexes of phytocenoses, which is highly variable, but in most cases it is more than 100 m² and less than 1 km².

During many years' field investigations in the surroundings of the town Suwalki (NE Poland), several types of the local complexes of phytocenoses were distinguished and described. I want to present three of them, with the shortened characteristics, as an example of units of this kind. All the types presented below are located in the *Tilio-Carpinetum* habitat.

The first type is connected with the low buildings and the area of small rural settlements. The area occupied by a single complex is of about 2000–100 000 m². The characteristic feature here is the lack of a vegetation on 20–80% of the total territory occupied. The complete register of plant associations contains 12 items, but only two, i.e. *Lolio-Plantaginetum* and *Arrhenatheretum* are the principal associations. As the specific associations are regarded: *Leonuro-Arcetietum*, *Urtico-Malvetum*, *Potentillo-Artemisietum*, *Lolio-Plantaginetum* growing in a form of big spots and fragments of associations from *Polygono-Chenopodietalia*, mainly of *Galinsogo-Setarietum* and *Veronico-Fumarietum*.

The second type is that of open fields. The area occupied by a single complex is of about 10–50 ha or more. The complete register of plant associations contains 17 items, of which four are principal ones, i.e. *Arrhenatheretum*, *Lolio-Cynosuretum*, *Consolido-Brometum* and *Veronico-Fumarietum*. The last three, together with *Echio-Melilotetum*, *Tanaceto-Arte-*

misietum, *Centaureo-Berteroetum*, *Prunetalia* and *Lolio-Plantaginetum* occurring in a linear form are also specific associations.

Sometimes *Polygalo-Nardetum*, *Pinus silvestris* populations and fragments of sandy grasslands from *Festuco-Sedetalia* occur, but they are alien cenotaxa.

The third type is that of woody territories. The area occupied by a single complex is more than 50 ha. The complete register of plant associations contains 11 items, but only three, i.e. *Tilio-Carpinetum*, *Rubo-Salicetum* and the young forest with the dominance of *Picea excelsa*, are principal associations. *Tilio-Carpinetum*, *Trifolio-Agrimonetum*, *Prunello-Plantaginetum* and *Fragarion* are specific communities.

As it can be easily seen, the local complex of phytocenoses might be compared with the vegetation aspect of some basic units of the complex physico-geographical system. It seems that the "suburotshistshe" (poduroczysko; KONDRACKI 1976) is a parallel category of this kind.

The vegetation landscape

The real vegetation landscape is the second main unit of a vegetation spatial organization above the phytocenose level. It comprises different habitats, distributed in a special way in a space occupied by diverse local complexes of phytocenoses.

Despite a succession of phytocenoses and their complexes, the vegetation landscape is a stable unit and persists for some hundred years, as long as no catastrophic events occur (mainly due to drastic changes in land use, e.g. deforestation, construction, etc.).

In most cases different habitats are regularly placed in a space, but the same can not be said about local complexes of phytocenoses, because of a very complicated pattern in their distribution.

It seems that the real vegetation landscape is the smallest unit of regional character and it ought to be taken into consideration during geobotanical regionalization.

The complete description of the character of the individual vegetation landscape contains:

- the area of the landscape;
- the register of all types of local complexes of phytocenoses together with their area and the type of habitats occupied;
- the distinction between principal and supplementary types of local complexes of phytocenoses;
- the value of the area fragmentation index;
- the outline of vegetation catenas occurring;
- the main directions of land use.

The analysis and comparison of individual, real vegetation landscapes makes it possible to define their types. A main criterion for a general similarity is the resemblance of vegetation catenas and the pattern of distribution of phytocenoses in local complexes.

The area occupied by a vegetation landscape is from several km² to few hundred km² or even more.

Investigations carried out up to now have shown that in most cases there are less than one hundred local complexes of phytocenoses belonging to less than ten types in the composition of a separate vegetation landscape. However, proportions might be quite different in the different regions.

As an example of the unit described above the meadow-forest-marsh-field system occurring on a flat surface with sporadic small hills might be mentioned. There are *Tilio-*

Carpinetum habitats on these hills, occupied by the open-field-type local complexes of phytocenoses.

On the remaining area the habitats of *Circaeo-Alnetum* and *Carici-Alnetum* prevail with the addition of some *Vaccino uliginosi-Pinetum*. There are three principal types of local complexes of phytocenoses here, the first one with the dominance of *Cirsietum rivularis* and the meadow of *Cirsio-Polygonetum* type (the *Circaeo-Alnetum* habitat), the second with the dominance of *Salicetum pentandro-cinereae*, *Salicetum repentis* and *Carici-Agrostietum* (the *Carici-Alnetum* habitat) and the third with the dominance of *Carici-Alnetum* and different fragments of *Magnocaricion* associations (*Carici-Alnetum* habitat).

It seems that for the unit understood as above, the microregion or terrain (KONDRACKI 1976) is the parallel physico-geographical category.

Other categories

Beyond the distinct and autonomous units like the local complex of phytocenoses and the vegetation landscape, comprising natural, holistic, ecological systems, there are other spatial categories of vegetation.

One of them is a group of dependent communities. It is composed of communities always (or almost always) occurring together e.g. the *Fagetalia* forest with the *Trifolio-Geraniea* community and the epiphyte community, or *Salicetum pentandro-cinereae* with *Filipendulo-Geraniea* and *Convolvuletalia sepium*.

Without any doubt, the group of dependent communities is an ecological unit, but, in fact, it has no real spatial sense. Nevertheless, it is part of the local complex of phytocenoses and it must be taken into consideration in course of the complex describing.

The other additional unit is the vegetation catena. It illustrates an arrangement of a vegetation along gradients of environmental factors (pH, humidity, nitrogen contents, etc.). It has a linear character rather than spatial. The vegetation catena shows connections among phytocenoses but it does not reflect all the spatial differentiation, often subdividing natural systems. That is why it can not be treated as an autonomous level of vegetation organization.

The above-described categories are not independent spatial units, nevertheless they might be the basis for delimiting landscape vegetation units, as it was done by MATUSZKIEWICZ (1979), ARMAND (1980), CZERWIŃSKI (1981) and others.

Final remarks

Every spatial unit based on the real vegetation is part of the exactly defined landscape unit based on potential vegetation. From the theoretical point of view it is possible to construct a uniform hierarchic system of landscape vegetation units without any inner contradictions, integrating the system presented above with approaches of SCHMITHÜSEN (1968), MATUSZKIEWICZ (1979), RADKE (1980), PLIT (1981) and others, based on the TÜXEN's (1956) potential vegetation principle.

Based on the hypothesis that each phytocenosis reflects a biocenosis and an ecosystem (MATUSZKIEWICZ, W. 1974), all the landscape vegetation units are, at the same time, complex geographical landscape units. That is

why they might be used for the completion of the characterization of other spatial units. Also, the system of the spatial units of the real vegetation shows some similarities to different systems based on geomorphology and/or land utilization, e.g. the phyto-geomorphic system of HOWARD and MITCHELL (1980).

There are great perspectives for applying landscape vegetation units, first of all for regionalization and for the complex evaluation of the environment.

The system of landscape units based on the real vegetation has been applied not only for describing individual regions, but also for the optimization of land use directions, evaluation of turistic features and evaluation of anthropogenic changes.

REFERENCES

- Armand, D. L. (1980): *Nauka o krajobrazie* (The Landscape Science). PWN, Warsaw.
- Balcerkiewicz, S., Wojterska, M. (1978): Sigmassoziationen in der Hohen Tatra. *Berichte der Internationalen Symposien der Internationalen Vereinigung für Vegetationskunde. Assoziationskomplexe (Sigmeten)*, 161–177.
- Beguín, C., Hegg, O. (1975): Quelques associations d'associations (sigmassociations) sur les anticlinaux Jurassiens recouverts d'une végétation naturelle potentielle. *Documents phytosociologiques*, fasc. 9–14, 9–17.
- Beguín, C., Hegg, O. (1976): Une sigmassociation remarquable au pied du Premier Anticlinal Jurassien. *Documents phytosociologiques*, fasc. 15–18, 15–24.
- Berg, L. S. (1958): *Die geographischen Zonen der Sowjetunion*. Leipzig.
- Czerwiński, A. (1981): Ukształtowanie naturalnej roślinności leśnej na tle rozwoju procesu glebowego w wybranych obiektach północno-wschodniej Polski (The form of natural forest vegetation in comparison with the development of soil processes in chosen regions of NE Poland). *Zesz. Nauk. Pol. Białost. Nauki Techniczne* 34, Białystok.
- Doing, H. (1979): Gesellschaftskomplexe und Landschaftskartierung. Methodische und praktische Überlegungen. *Ber. Geobot. Inst. Eidgenoss. techn. Hochsch. Stiftung Rübel* 46: 31–61.
- Granö, L. G. (1929): *Reine Geographie*. Acta Geogr. 2, Helsinki.
- Howard, J. A., Mitchell, C. W. (1980): Phyto-Geomorphic Classification of the landscape. *Geoforum* 11: 85–106.
- Ilin, I. S. (1975): Nyekotorye voprosy obyektivizacii geobotanitseskovo rayonirovaniya (Some questions about the objectivisation of geobotanical regionalization). *Dokl. Inst. Sibirii i Daln. Vost.* 48: 49–55.
- Isatchenko, T. I. (1966): *Izutshenye i kartografirowanye struktury rastitelnogo pokrova* (Investigations and Mapping of the Plant Cover Structure). Riga.
- Kondracki, J. (1976): *Podstawy regionalizacji fizycznogeograficznej* (The Basis for Physico-geographical Regionalization). PWN, Warsaw.
- Matuszkiewicz, J. M. (1979): Landscape phytocomplexe and vegetation landscapes, real and typological landscape units of vegetation. *Documents phytosociologiques N. S.* 4: 663–672.
- Matuszkiewicz, W. (1974): Teoretyczno-metodyczne podstawy badań roślinności jako elementu krajobrazu i obiektu użytkowania rekreacyjnego (Theoretical-methodical basis for studying vegetation as the landscape element and the object of recreational use). *Wiad. ekol.* 20: 3–13.
- Medwecka-Kornaś, A. (1976): Metody i problemy kartografii fitosocjologicznej (Methods and problems of phytosociological cartography). *Zesz. Nauk. UJ, Prace geogr.* 45: 101–121.
- Neef, E. (1967): *Die theoretischen Grundlagen der Landschaftslehre*. Gotha, Leipzig.
- Passarge, S. (1919): *Die Grundlagen der Landschaftskunde*. Hansa Verlag, Hamburg.
- Plit, J. (1981): The map of potential natural vegetation as a basis for comparative studies and geobotanical regionalization. *Acta Soc. Bot. Pol.* 50: 515–540.
- Radke, G. J. (1980): System of ecologic and geographic landscape classification, shown in the central European region. *Acta Bot. Acad. Sci. Hung.* 26: 169–180.
- Ratskovskaya, A. S. (1963): Tipi kompleksov rastitelnogo pokrova sukhoy stepi Centralnogo Kazakhstana i ikh klasyfikacya (The types of plant cover of the dry steppe in Central Kazakhstan and their classification). *Tr. Bot. Inst. AN SSSR, geobot.* 15.

- Schlüter, H. (1979): Vegetationsform und -mosaiktyp als vegetationsgeographische Raumeinheiten. *Wissenschaftliche Mitteilungen I, Inst. d. Geographie u. Geoökologie d. AdW*, 32–39.
- Schlüter, H. (1980): Zur Frage vegetationsgeographischer Raumeinheiten. *Acta Bot. Acad. Sci. Hung.* **26**: 185–190.
- Schmithüsen, J. (1968): *Allgemeine Vegetationsgeographie*. Berlin.
- Tüxen, R. (1956): Die heutige potentielle natürliche Vegetation als Gegenstand der Vegetationskartierung. *Angew. Pflanzensoziologie* **13**: 3–42.
- Tüxen, R. (1973): Vorschlag zur Aufnahme von Gesellschaftskomplexen in potentiell natürlichen Vegetationsgebieten. *Acta Bot. Acad. Sci. Hung.* **19**: 379–384.

BOOK REVIEWS

Editor: G. FEKETE

LYONS, J. M.-VALENTINE, R. C.-PHILLIPS, D. A.-RAINS, D. W.-HUFFAKER, R. C. (eds): Genetic Engineering of Symbiotic Nitrogen Fixation and Conservation of Fixed Nitrogen. Plenum Press, New York-London 1981

This volume comprises the papers presented at the Symposium on: "Enhancing Biological Production of Ammonia from Atmospheric Nitrogen and Soil Nitrate" held at Lake Tahoe, California in June, 1980. The meeting and accordingly this volume focuses on enhancing the efficiency of nitrogen fixation, bridging the gap between the rhizobial microsymbiont and its host plant with emphasis on the fundamental biology of the symbiosis. Incorporating the work of scientists from several disciplines, the book develops a basic understanding of the genetics, physiology and biochemistry of symbiotic N_2 fixation, the acquisition and assimilation of fixed nitrogen and the effects of denitrification on fixed nitrogen. Many traditional genetic techniques being used to solve problems related to N_2 fixation, NO_3^- utilization and NO_3^- conservation are outlined. Furthermore some of the first attempts to provide solutions through methods of genetic engineering are also reported.

The main chapters are: "Genetics and regulation of nitrogen fixation", "Plant factors impacting nitrogen assimilation", "Nitrogen fixation by nonlegumes", "Conservation of fixed nitrogen".

This volume will be worth-while reading and of primary importance to researchers and workers in genetics, agronomy and botany as well as biochemistry and photobiology.

I. GYURJÁN

ROODYN, D. B. (ed.): Subcellular Biochemistry. Vol. 8. Plenum Press, New York-London 1981

This is a new book in this series, dealing with the biochemistry, biogenesis, structure and evolution of cell organelles and membrane systems.

The first chapter, published by J. OELZE, is concerned with a detailed account of the composition and development of the bacterial photosynthetic apparatus. A number of photosynthetic bacteria are discussed, with particular emphasis on the well-studied *Rhodospirillum rubrum* and *Rhodopseudomonas spheroides*. A model of the arrangement of membranes in the cell and of functional systems in membranes of a phototrophic bacterium is presented.

In the second chapter, A. C. BAKKE and R. A. LERNER summarize the changes in membrane structure during development of *Dictyostelium discoideum*. This slime mould can exist in a vegetative form as a conventional "amoeba". However, under appropriate conditions it is transformed into a multicellular organism. The plasma membranes have been studied at every stage and the results of such studies are summarized in this chapter.

The next chapter systematically surveys the current knowledge of the biochemistry of the microtubule system and of the mechanism of microtubule assembly. One section deals with recent experiments on the cloning of the tubulin gene by B. B. BISWAS, A. C. BANERJEE and B. BHATTACHARYA.

Next is dealt with the question of the relationship between nucleus and cytoplasm. A. V. LICHTENSTEIN, M. M. ZABOYKIN, V. L. MOJSEEV, V. S. SHAPOT are particularly concerned with how the flow of genetic information from nucleus to cytoplasm is controlled. They make some fascinating suggestions about the possible role of ubiquitous nuclear pores in the process.

The fifth chapter is a short summary of the main metabolic transformations of vitamin D. Here the subcellular localization of various hydroxylase systems involved in these transformations is discussed.

The next chapter deals specifically with receptors of fundamental importance, namely those of acetylcholine. Models of the molecular organization of acetylcholine receptor complex are given. A survey of the distribution of acetylcholine receptors, their composition, structure, and morphology, and the differences between junctional and extrajunctional receptors can also be found.

An article, by A. R. POOLE, describes the application of modern immunological techniques to the study of tissue proteinases. Moreover, the intra- and extracellular localization of cathepsin D is discussed. He includes a most useful section entitled "Immunological Methods for the Study of Proteinases" with helpful advice on the preparation of antibodies, immunoprecipitation, immunoinhibition, immunolocalization, etc. The article shows strikingly how current advances in immunology may be usefully applied, to the study of the tissue and intracellular distribution of specific enzyme molecules.

The final chapter is a brief, critical and stimulating account by S. W. FOX, K. HARADA and P. E. HARE of studies that have been made to establish the significance of the trace amounts of amino acids that have been detected in samples of lunar rock and in the core of various meteorites.

The volume includes an extensive book review section elaborating on certain aspects such as recognition systems, methodology, cell biology, and evolution and many topics discussed are related to chapters in the reviewed volume.

A. H. NAGY

BROWN, R. M. Jr. (ed.): Cellulose and Other Natural Polymer Systems. Plenum Press, New York 1982, pp. 519, IV plates

It is surprising that we know very little about how cellulose, the most abundant macromolecule on earth, is synthesized. In spite of the tremendous economic potential for wood and cellulose products, and in spite of the vast accumulation of scientific data on the composition and structure of wood and textiles, the mechanism of cellulose biogenesis are much less understood than one might have suspected. Repeated attempts to assemble cellulose microfibrils in vitro have been made without success, yet a close relative, chitin, has been synthesized in microfibrillar form in vitro.

Cellulose, chitin, lignin and other natural polymer systems are so common and widespread in the living systems, and are so essential to our daily lives that it is of great importance that we strive to better understanding how these products are assembled by living cells. Because these are complex, interdependent systems, the skills and efforts of biochemists, molecular geneticists, and physicists are needed to help solve the many extremely complex and difficult problems in the field.

In spite of the relative paucity of information on cellulose microfibril biogenesis, we have begun, at last, to make progress in the area. A treatise dealing with the subject is needed. New technological discoveries and approaches have provided us with a better understanding of how the cellulose microfibril is assembled.

In this volume, some of the most recent and innovative approaches are presented dealing with the biochemistry, macromolecular structure, and cytology of cellulose and its assembly and degradation.

Focusing on the composition, biogenesis, and degradation of cellulose, this book surveys basic research on the biosynthesis and structure of diverse natural polymer systems, including those of bacteria, algae, and insects, as well as higher plants.

Although the work concentrates on cellulose as a natural polymer system, it contains important chapters concerned with the macromolecular structure of the polymer and the role of cellulose in plant growth and development. Natural polymer systems are compared with man-made fibers, and other, noncellulose cell wall components such as hemicellulose, callose, chitin, proteins, and glycoproteins.

The volume contains 23 papers from 29 authors (mostly from the USA and Canada), and has three main sections.

I. Biogenesis. The first section gives the three quarters of the whole volume: 18 papers. The main topics are: the microfibril assembly of cellulose in vivo, cytological models of cellulose biogenesis, cell-wall formation, assembly and localization of wall polymers, the inter-

action of cell-wall formation and cell division, cell-wall regeneration by protoplasts, microfibril-tip growth and the development of pattern in cell walls, the role of the GOLGI-apparatus in the biosynthesis of natural polymer systems, callose-deposit formation in root hairs, chitin-fibril formation in algae, synthesis of chitin microfibrils in vitro, the control of molecular weight and its distribution in the biogenesis of cellulose, *Acetobacter xylinum* as a model system for cellulose synthesis.

Several papers deal with the biosynthesis of diverse glycoproteids, callose and other natural polymers.

The plants studied range from bacteria (mostly *Acetobacter* species) to algae and higher plants.

II. Structure. The formation and structure of cellulose microfibrils are investigated by various technics of X-ray diffraction, autoradiography, scanning and high resolution electron microscopy, etc. The results give us a detailed and up-to-date overall picture of the cross-sectional, internal, lateral, and longitudinal structure of cellulose microfibrils as well as the accurate dimensions of them.

Similar tools are used to discover the structure of chitin microfibrils and that of the chitin-protein complex. Comparisons between synthetic man-made, and natural microfibril systems show that all these systems can be described through the formalisms of nonequilibrium thermodynamics.

III. Degradation. The decomposition of natural polymers has equal importance to the synthesis of them. For catabolizing cellulose, chitin and other natural polymers, there are present in nature a number of enzymes. In higher plants these are involved in cell growth and division, differentiation; maturation of fruits, invasion of foreign organisms (e.g. fungi) through wounded tissues, callose deposition, symbiosis of nitrogen-fixing bacteria with plants, etc.

Litter decomposition, wood decay, digestion and many other important natural processes are in close connection with catabolizing cellulose and chitin.

Cellulase enzymes have a specially promising future in the possible conversion of waste cellulose into glucose, and further, ethanol.

The whole volume is well-documented with many excellent microphotos and color plates. Each chapter is followed by bibliographies. An overall subject index is included. This well-edited book will most certainly be welcomed by cell biologists, biochemists, biophysicists, molecular geneticists, and other experts of natural polymer systems.

Z. Szócs

JOHRI, B. M. (ed.): *Experimental Embryology of Vascular Plants*. Springer Verlag, Berlin-Heidelberg-New York 1982, pp. 273

This book on experimental embryology of pteridophytes, gymnosperms and angiosperms contains a wide range of topics including flower, anther, ovary, ovule and nucleus culture, pollen-pistil interaction and control of fertilization, endosperm, embryo and protoplast culture.

First part of the book is devoted to experimental embryology of pteridophytes (Chap. 2 by A. E. DE MAGGIO), gymnosperms (Chap. 3 by K. NORSTOC), and angiosperms (Chap. 4 by R. N. KONAR and S. KITCHLUE). Each chapter is self-contained, the text and legends have not been loaded with too many details of media but these can be found in the references. The significant achievements and many of the unresolved problems have been so rapid that a comprehensive review is no more possible.

Chapter 5 deals with the problems of anther culture. During the last ten years the most spectacular achievement seems to be the in vitro development of haploid plants from pollen. After the discovery of the origin of haploid plants from pollen through anther culture by GUHA and MAHESHWARI (1964) the next step was to culture isolated pollen grains. C. NITSCH (1976) has given an excellent technique for pre-training of anthers and isolating pollen grains. She (1977) also discusses the advantages of isolated microspore culture over anther culture. In this way the possibility of diploid callus from anther tissue is avoided. The production of a large number of haploids and homozygous diploids is of great importance to geneticists.

The successful cultivation of pollinated ovaries with proembryos and free nuclear endosperm has made it possible to culture ovaries and ovules with the zygote and primary endosperm nucleus (Chap. 6). Test tube fertilization of gynoecia, placenta with ovules (Chap. 7) is a great step forward in removing barriers to crossability and obtaining intergeneric and interspecific hybrids.

Chapter 8 is devoted to endosperm tissue, which was considered to be "dead" and incapable of undergoing morphogenesis. Since 1965 endosperms have been successfully cultured and organogenesis also achieved. A number of diverse taxa have yielded callus of unlimited growth and differentiation leading to triploid roots, shoots and even plantlets in about a dozen taxa.

The problem of protoplast culture also deserves to be mentioned, though this may not directly pertain to experimental embryology. However, embryogenesis does occur in protoplasts of a number of taxa (Chap. 10). Some other aspects of protoplast culture have also been considered for the sake of a comprehensive coverage.

The authors of the individual chapters are wellknown specialists in their respective fields and they emphasize the relevant aspects of vital importance. Professor JOHRI's short but interesting introduction (Chap. 1) makes this book complete.

This book is invaluable not only for undergraduate and postgraduate students but also for those — first of all research workers — interested in understanding this subject and making use of the progress achieved so far.

A. BREZNOVITS

RUZICKA, J.: Die Desmidiaceen Mitteleuropas Band 1, 2. Lieferung. E. Schweizerbart'sche Verlagsbuchhandlung (Nägele u. Obermiller) 1981, pp. 736

We are glad to welcome the second volume of the *Desmiales* series. In this work the species of four genera (*Actinotaenium*, *Tetmemorus*, *Euastrum*, *Micrasterias*) are included. The book is written on a high level customary for the author and already well-known from the previous Lieferung. Here, his two basic principles are stressed, too. He refuses the changeable morphological marks (not fixed genetically), and he insists most rigidly on the specifications of the International Code of Botanical Nomenclature. The author believes that at least 50% of the taxa are uncertain because these are based on variable morphological differences. It would mean a great step in algology if this conception became general because it occurs also with other groups that if the variability of a species is controlled by cultivation then the seemingly different taxons are to be combined in the end. Ruzicka's relation to the Code is slightly ambivalent. He protects the prestige of the Code by pointing out the intolerable situation deriving from the fact that one part of the paragraphs is followed by certain taxonomists while those being unpleasant for them are ignored. At the same time he criticizes the Code sharply (and rightfully in our opinion) because it is not explicit enough and has a special legal terminology. Organization of courses for alga researchers would not mean a solution because these courses cannot be attended by each alga researcher. The text should be made more unambiguous, clear and an explicit, explained version is needed. The algologists have not taken the Code into consideration for a long time and now they protest mostly in vain that their special points of view are hardly taken into consideration. It would be a solution if more algologists of distinction could participate in the compilation of the Code. If it were represented in the section of Nomenclature of the International Botanical Congress according to its importance then, there would be an opportunity for having the desired changes accepted. But unreal aspirations should not be taken seriously. If up till now everybody has accepted the fact that the names of species cannot be conserved then, algologists, must do the same. On describing the individual species we can find the following entries, Differentialmerkmale, Taxonomie, Variabilität, Vorkommen, which are followed by the infraspecific taxons. The information obtained at the entry Taxonomy is extremely valuable. RUZICKA's sober mature taxonomic approach resembles perhaps only that of ŠKUJA. We cannot but admire the author's familiarity with the literature, as algology does not belong to the most preferred field of science. I recommend this book warmly to every algologist.

L. HAJDU

Medicinal and Aromatic Plants Abstracts. Reporting Current World Literature Publications and Information Directorate, CSIR, New Delhi

The bi-monthly journal "Medicinal and Aromatic Plants Abstracts (MAPA)" coming out is published by the "Publications and Information Directorate, CSIR" in New Delhi, in India. The Editing Commission of eight members is assisted in the preparation of the publication by a nine member advisory council consisting of internationally well-known scientists.

The aim of the journal is to follow the expansive publicistic activity in connection with the medicinal and aromatic plants, in the form of short abstracts. With this aim it is unique in the world, thus it represents a very important source of information for the experts studying the medicinal plants and secondary metabolic products.

Taking into consideration, the interdisciplinary character of the researches of medical plants also the published abstracts are grouped according to the partial sciences and the prospective field of application, respectively, thus for example "Agronomy; Botany; Breeding; and Genetics; Diseases and Pests; Physiology and Toxicology; Antimicrobial Activity; Insecticidal and Piscicidal Activities; Phytochemistry; Chemotaxonomy; Ethnomedicine; Analytical and Processing Techniques; Miscellaneous; New Publications". This promotes the coverage of the activity of the experts working in the same field of research but studying different plants. The quicker and more special gathering information is facilitated by a Keyword Index.

Besides the abstracts, the reader may also gather information about the individual congresses as well as, under "Bibliography", about the complete collection of the publications of different character, relating to a given, chosen species, e.g. *Tylophora Indica* (Vol. 3, No. 1).

The number of publications treated by the MAPA is well demonstrated by the fact that of 109 journals (these are included in a separate list) 739 abstracts are published in English e.g. in the issue of February 1981, with the addresses of the authors, besides their names also given.

Most of the journals in the issue in question are Indian. This fact is favourable for the European reader because in this way one can easily gather information also on the hardly accessible publications of India carrying out significant researches for medicinal plants. It can be set down as a faultiness that only the most important international journals are surveyed while several journals with publications on medicinal plants are issued e.g. *Herba Hungarica*, *Acta Botanica* (Budapest), etc. are left out of consideration. It can also be mentioned as a drawback that also of the published journals on positively medicinal plants the studies are made known only with selection; disproportions can be found also in the depth of the representation.

In spite of the above-mentioned drawbacks which may be attributed also to the character of the journal, the MAPA is a modern, well-edited, new, long-needed abstracting journal, which is indispensable for the experts dealing with the medicinal plants and is at its readers' disposal at a relatively moderate cost, its annual subscription price is 17 \$.

I. MÁTHÉ

SYMON, D. E.: A Revision of the Genus *Solanum* in Australia. Journal of the Adelaide Botanic Gardens, Vol. 4, 1981. 367 pp., 167 drawings, 21 sketch maps

This book gives a description and critical survey of the *Solanum* genus species occurring in Australia. 125 species are discussed in detail in this book, of which 94 are of Australian origin, of these 15 are new species described by the author while the others are not of Australian origin but can be found in the flora of Australia.

The short historical survey of the taxonomy of the discussed Solanums is followed by chapters on general morphology (root, leaf, stem, thorns, pubescence, inflorescence, flower, fruit, seed) then after a germinative and cytological survey of barely one page, the individual species are systematically discussed on about 200 pages. The course of this is as follows: the type citation is followed by the lectotype citation, then come the detailed literary citations relating to the species, which are followed, after mentioning the vernaculars, by the botanic description of the plant with habit drawings, then the variants (ssp., var.) are given. Thus, for example, six variants are mentioned in the *Solanum aviculare*, for the culture for pharmaceutical industry of which cultural experiments have been and are being tried. Var. 1 *acutifolium*, var. 2 *brisbanense*, var. 3 *grandiflorum*, var. 4 *grandifolium*, var. 5 *hybridum*, var. 6 *patulum*. Characterizing these marked variants the practical note is also included that the solasodin contents of the hybridum var. is 1.5–1.8%, while that of the *patulum* var. is 2.1–2.6%.

The remark is made on the *Solanum dulcamara* studied in detail in Hungary that this plant is considered to be a potential alkaloid source for making steroid drugs in several works, partly in Eastern Europe, but literature references are not mentioned. Hungarian publications are not referred to with the *Solanum nigrum* discussed in detail, either.

The taxonomic key used for the determination of the discussed species is well supported, besides the habit drawings, by the tables illustrating the fruit embranchments, fruit forms, stamina, fertile parts (ovary, stigma). In the long list at the end of the work, containing

almost 700 literature data, some Hungarian authors are also included but the bibliography of the recent Hungarian results is not to be found. On the whole, it is long-needed work, which is indispensable for all experts studying the genus *Solanum*. I. MÁTHÉ

HORTOBÁGYI, T.-SIMON, T. (eds): *Növényföldrajz, társulástan és ökológia* (Plant Geography, Plant Sociology and Ecology). Tankönyvkiadó, Budapest 1981; pp. 546

The book edited by HORTOBÁGYI and SIMON was published under the auspices of Tankönyvkiadó with the collaboration of the Hungarian experts of synbotany as the third and last part of the text-book series embracing the branches of botany. It gives an excellent summary of theoretical and practical knowledge of plant geography, plant sociology, ecology and the protection of the environment and nature.

The work is divided into three main chapters and one dealing with the protection of the environment and nature.

Chapter 1 presents the vegetation zones of the Earth and the most important vegetation types within them on the basis of the classical and up-to-date results of plant geography. Furthermore it covers the composition of the Hungarian flora and extends to the plant geographical classification of Hungary. The author summarizes the fundamental ideas of plant geography and gives a short survey of the history of this science. The chapter is illustrated by a great deal of original photos, maps and figures.

In the second chapter the characteristics and regular phenomena of plant populations and plant associations are dealt with. There is a clear description on the analytic and synthetic features of associations and classical and modern methods of investigations as well as the structural characteristics of plant association. Finally the most important plant associations of Hungary are discussed.

In chapter 3 a team of authors have undertaken a comprehensive review of the latest results of ecology. Following the ecological fundamental conceptions and the ecological niche concept it is concerned with the effects of biotic and abiotic environmental factors (light, heat, water, air, soil, etc.) on the vegetation. Principles of bioclimatology, bioclimatological types and their correlations to zonal vegetation are also treated. The life-form types, the ecological species groups and the artificial regulation of environmental factors are outlined briefly. A special part deals with the regularities of the formation, development and function of ecological systems, with the role and the characteristics of structural elements. The matter circulation and the energy flow of systems and factors influencing them are treated too. Finally a survey of the most important ideas and rules of the plant production biology is given.

At the end of the book a short chapter connected with the three main ones covers the protection of the environment and nature. It presents the history of the protection of the environment and nature of Hungary providing data on its present situation and future tasks. It gives a short review of the legal system and the official organization of the protection of nature and calls attention to the importance of the principles and methods of the protection of wild animals, plants and plant associations. Some tables summarize and a map illustrates the important protected areas and national parks of Hungary.

The maps showing the natural vegetation of Hungary (after ZÓLYOMI) and of the Earth (after PÓCS) are attached to the book as supplements.

The work is a uniform text-book for Hungarian tertiary education of botany and summarizes the curriculum with a production biological background. Apart from the theory it treats public health, agricultural and industrial aspects. It has been compiled not only for students, it may be useful for anyone interested in botany as well. G. BUDAY

GOOD, R. E.-WHIGHAM, D. F.-SIMPSON, R. L. (eds): *Freshwater Wetlands. Ecological Processes and Management Potential*. Academic Press, New York 1978, pp. 378

This book comprises the material of a conference entitled "Freshwater Marshes: Present Status, Future Needs", held 13-16 Feb. 1977 at Rutgers, The State University of New Jersey, New Brunswick, New Jersey. The conference worked in four sections: Primary production, Decomposition, Mineral cycling and Management potential, summarizing the knowledge of 1977 on freshwater wetlands ecology in USA and Canada.

The book is also divided into four major parts: Primary production processes, Decomposition processes, Nutrient dynamics and Management potential. Each contains several contributions with illustrations and references and a "Summary and Recommendations" written by the session chairman.

Freshwater wetland can be considered from different points of view. Let us take for example two extreme opinions: (i) these areas are useless wastelands and can be used only by expensive drainage and/or as deposit area for human waste products; (ii) from the point of view of a limnologist, these areas are complex systems of extreme importance as resources or special natural barriers and/or sieves around lakes — especially shallow lakes — retarding the nutrients and delaying eutrophication. Freshwater wetlands are moreover very different as landscapes of unique beauty. This variability, however, causes difficulties in uniform management, research and evaluation. Types of freshwater wetlands vary very widely, e.g. from marshes of glacial origin to prairie wetlands, swamps, etc. Therefore the problems arise already at the definition stage.

Part I deals with primary production processes. This part contains five studies on the above-ground primary production of entire communities as well as several species. Several methods (e.g. measuring peak biomass, maximum minus minimum biomass, disappearance methods, multiple harvest, gas exchange) and the reasons for underestimation (e.g. ignorance of herbivory, leaf mortality, turnover) are discussed. In contrast with the above-ground production, greater efforts should be taken to estimate the below-ground production. The role of species' life histories in the primary production is also emphasized. The last paper of this part is concerned with the key role of the hydrologic regime of wetland ecosystems on the basis of a general conceptual model. The source, velocity, renewal rate and timing of water seem to be the major controlling factors. Their effect on spatial heterogeneity, nutrient cycles and distribution, structural and functional characteristics are also discussed.

In Part II decomposition processes are discussed. From the papers of this part we can get a picture of decomposition based on various field and laboratory experiments. Several plant species (e.g. *Peltandra*, *Nuphar*, *Pontederia*, *Zizimia*, *Sagittaria*, *Carex*, *Typha*, *Sparganium*, *Najas*, *Myriophyllum*, *Salix*, *Betula*, etc.) are examined under various conditions (e.g. aerobic, anaerobic conditions at different temperatures, litterbags exposed on the peat's surface, in the water, on the soil-water interface). The process of decomposition was followed by measurement of weight loss, loss in different elements (N, P, Ca, K, Na, Fe, etc.), changes in C : N ratio. Decomposition rates, turnover times and elemental mobility are also determined. Some of the studies are devoted to the approximation of the patterns of element flow. Content, flow and release of different elements (N, P, K, Ca) during decomposition in the standing litter-fallen litter-rhizomes-water system were investigated in three-year field experiments. As in Part I the results and conclusions are supported by a great number of data and a general conceptual model of decomposition in freshwater marsh plants is also outlined.

Part III contains five papers of nutrient dynamics. The first one gives us information on the chemical composition and energy content of plants. The variation in the composition was the lowest in the within-site intraspecific case, higher in between-site intraspecific case and the highest at the interspecific case. Energy content values were more constant than chemical parameters. The second paper is concerned with the question of nutrient movement through lakeshore marshes based on the study of phosphorus uptake and allocation in *Typha latifolia*. Finally a mass balance model for nutrient transport through lakeside marshes is offered. The nutrient dynamics of riverine marshes is the topic of the next study from a point of view of the emergent plants-water-soil system depicting the nutrient flow in a *Scirpus fluviatilis* stand. The next paper is concerned with the dynamics and cycling of nutrients in four northern wetland types (fens, bogs, swamps and marshes). On the basis of the content, exchange, seasonal pattern of nutrients of various compartments (e.g. soil, water, plant) and the ecosystem too, models of annual N, P, Ca fluxes and pools are depicted. The last review of this part is a study of the seasonal movement of dissolved nutrients in a freshwater tidal marsh. Hydrological changes cause different patterns of nutrient distribution which is strongly affected by the macrophytes, too.

Part IV deals with management potential. The papers of this part of course could not cover the entire scope of wetland management, they are rather illustrations on some of the problems in this field, e.g. wildlife, management nutrient transformation processes involving wastewater treatment, problems of canals, wetland regulation and planning, renewal damaged wetlands, creation of marshes de novo for several purposes, etc. For better management it is not enough to have a scientific understanding, the cooperation of scientists, laymen, planners, administrators and managers is needed.

Although the studies and the numerical data originate from the region of USA and Canada, an European scientist can make use of them. The "Summary and Recommendations" in the final papers of the separate parts are very useful and valuable. They give us a brief state-of-the art of the four topics and a summarized overview of future needs and tasks and recommended methods.

J. NOSEK

VAN DEN BOSCH, R.-MESSENGER, P. S.-GUTIERREZ, A. P.: *An Introduction to Biological Control*. Plenum Press, New York-London 1982, XIV + 247 pp.

The increasing world-wide efforts which aim to reduce environmental pollution, among others to limit the use of pesticides, have given a new impetus to research and development in methods of biological control of pests and weeds. While chemical control of pest organisms can be carried out successfully even without special training, the use of most biological control methods entails much more detailed knowledge of the target organisms, the organisms used for control, the possibilities of combining these methods with other available means of control, and their economic aspect.

This book is a concise, updated, excellent overview of the principles and modes of application of biological control methods. It is designed for undergraduate students in the areas of pest control, agronomy, and ecology and it is also of interest to students of botany and agricultural economics.

The two opening chapters deal with definitions and outline the major areas where biological methods of control can be used. They also give a concise overview of the main principles of population ecology as the basis of natural control. The chapter on the history and development of biological control contains a short description of historical highlights from the ancient origins through some major achievements till the activities of present international organizations in this field. The characterization of entomophagous insects, their main types, modes of reproduction, and host specificity are discussed in a separate chapter. The fifth chapter deals primarily with the definition and scope of microbial control, as used for pest insects, and, to a lesser extent, with the control of weeds and plant pathogens. Nematodes are also considered as "microbial control" agents because of the techniques involved in their application. The comparatively large Chapter 6 treats the natural-enemy introduction process as the essence of classical biological control, from the identification of the pest as an exotic species to the design of quarantine and mass culture insectaries as well as the evaluation of natural enemies. The life table analysis as a major method in population ecology, the use of models for population dynamic studies and their applicability to the evaluation of biological control programmes are dealt with in Chapter 7. The factors affecting success or failure of introduced natural enemies and an analysis of classical biological control programmes are discussed in the following two chapters. The authors emphasize that although most attempts in classical biological control either have been a total failure, or have been only partially successful, by 1976 approximately 128 species of pest insects and weeds were completely or substantially controlled by imported natural enemies in many parts of the world. Several cases are discussed illustrating certain problems, approaches, or phenomena that have recurred in classical biological control programs. A separate chapter outlines the principles of integrating naturally occurring biological control into control measures against agricultural pests by developing integrated pest management. It treats the inevitable ecological and economic backlashes that occur where pesticides are used, the conflicts between private and societal goals in using pesticides, the economic perspectives of integrated control programs, and the research going on in this field. In order to complete the picture of biological approaches in pest control, Chapter 11 briefly surveys the biological control of vertebrates and dung as well as other kinds of biological control methods like crop plant resistance, cultural control, sterile insect release method, and other genetic manipulations. Chapter 12 contains data on estimated savings to the agricultural industry in California through major successful biological control projects in the last fifty years. It also deals with cost-benefit estimates, state and federal budgets for imported biological controls, costs of introduction, and the economic feasibility of using inundative release programmes of natural enemies in conjunction with environmental manipulation (e.g.: selective use of insecticides) to enhance the naturally occurring enemy complex for several crops in California. Finally the authors expound their view on the future of biological control. They emphasize that this method is a great biotic force that helps regulate pest populations and may have an important bearing on man's future success as a species on this planet.

Each chapter is completed with a list of well selected references.

An appendix with a list of species cited in the text, a glossary explaining the main terms used, and a detailed index facilitate the reader's fast orientation in this excellent book.

T. JERMY

JØRGENSEN, S. E. (ed.): *State-of-the-Art in Ecological Modelling*. Proceeding of the Conference on Ecological Modelling, Copenhagen, Denmark, 28 Aug.-2 Sept. 1978, pp. 891. I.S.E.M. Printed Fair-Print AS, Roskilde, Denmark 1979

The material of the conference first organized by the International Society for Ecological Modelling (ISEM) has been compiled in a book. It is divided into three parts following the system of the conference. Part A is about the eight state-of-the-art or review papers, Part B contains 29 different original papers and Part C is devoted to the summary of conclusions and future needs in eight topics (they are partly identical with that of Part A).

As the whole volume consists of 45 papers, only a brief overview will be given.

In his introductory words, A. K. BISWAS, the president of ISEM outlines the dramatic changes that have taken place in the last four decades. These imply the increasing need for more and more food, raw material, energy, etc., and at the same time a rapid increase in waste and residuals. "In many cases" as he writes, "we have already reached the point of no return, when we have already made irreparable damages to our environment". The solution of these problems created by ourselves, is not easy but we have already a few new tools. One of them is modelling. Further he makes us acquainted with the formation, objectives and future plans of ISEM.

Part A

In the first paper on river models, the author briefly outlines descriptive and predictive simulation, prescriptive optimization models, as well as some water quality and/or biocenotic models and case studies. He suggests that beside the recently used BOD₅ (biochemical oxygen demand in 5 days) and DO (dissolved oxygen) values, the COD (chemical oxygen demand), TOC (total organic carbon) and several ratios (TOC/COD, COD/BOD) should be applied in model building. Water quantity and quality management must be coupled more intensively in the future, too.

The second paper is devoted to the modelling of ecological processes and ecosystems with partial response structures. First several examples of response structure models are described and their advantages reviewed. Then a simple but surprisingly complex new analytical model and its application are discussed.

The use of microcosms for testing and development of models is introduced in the third paper. We can get an overview at a large scale of microcosm types and directions for future research.

The fourth paper deals with the predator-prey system modelling over 55 pages. This work covers the major problems in this field, e.g. the time-dependent and space-time-dependent models and/or deterministic and stochastic approach illustrated with many examples and new, unpublished results of the authors. Some of the questions discussed are for example: the relation between diversity and stability in predator-prey systems, the relation between complexity and stability in multi-predator-multi-prey models, numerical simulation of predator-prey populations spatial heterogeneities, etc.

Modelling of the fate of toxic chemical substances in aquatic environment is the topic of the fifth paper discussing several processes of chemical transformations and equilibria. To test the prediction an experimental environment is recommended.

The sixth paper presents an overview of modelling irrigated agricultures. The work is based on 43 computer models, giving a short evaluation of each, too. The major problem is that most of these models remain in theory should have to be implemented in practice.

A similar problem is discussed in the seventh paper where the authors have investigated the modelling of water pollution caused by irrigation. Their aim was to develop a model for salinity management and to optimize the strategy for the least costly salt reducing process.

The last contribution in Part A is devoted to the eutrophication models. As a survey of existing models has already appeared this is a discussion of the state-of-the-art. Several questions are touched, such as: to what extent can eutrophication models of today be used as management tools, is it possible to give some general lines about what such eutrophication models must include, or how will the next generation of eutrophication models be, etc.

Part B

In this section the original papers are presented. Unfortunately these can only be treated by giving a general and comparative picture.

The themes vary widely from the distribution of physico-chemical parameters and substances to modelling the whole ecosystem. Let us see the various topics: fate of atmospheric

fluorine; temperature, dissolved nutrients distribution, carbon exchange in estuaries and lakes; several management models e.g. flood plain, water quality management; waste-water application; different types of plankton models (e.g. multispecies effects, nutrient-effect, algal-bloom simulation based on experimental data, population dynamics in eutrophic shallow lake, effect of internal seiches on the population); predator-prey models; lichen reinvasion for monitoring ameliorating environments; groundwater models; ecological buffer capacity.

Some of these papers are devoted to the theoretical, mathematical problems of modelling, and in the actual studies such theoretical questions are often involved too. To illustrate these, let us see some examples: probability and stochastic aspect of modelling, discrete lake models, use of management models, development of efficient software for environmental models, sensitivity study, catastrophe theory, problem of simulations languages, the optimal combinations of inputs, application of microcosms, possibilities of the holistic approaches, etc.

The separate papers, both in Part A and B, are well illustrated with examples, figures, drawings, tables, flow charts, maps or even with life span matrices, program lists, formulas, equations and compartment diagrams. The excellent illustration facilitates comprehension the often difficult and complex problems. In addition, each paper has a reference list.

During the working sessions of the conference the state-of-the-art and the needs for future research of some selected fields were discussed, which led to excellent, concise but comprehensive summaries of the mentioned topics in the following fields: prey-predator models; lake and river models; application of microcosms; toxic substance models; hydrochemical modelling of irrigated agricultures; modelling sediment-water interaction; plankton models and holistic approaches to ecological modelling.

From this book, we can really get a comprehensive picture of several questions and recent problems of ecological modelling. Due to the numerous examples and references, the volume can be used almost as a manual, although it does not contain a total subject index.

J. N. NOSEK

ROMANS, R. C. (ed.): *Geobotany II*. Plenum Press, New York-London 1981, pp. 263

This book is the proceedings of the Geobotany Conference held at Bowling Green State University (Ohio), on March 1, 1980. It contains 11 papers of different, mainly paleobotanical, paleoecological topics.

The purpose of the meeting was to provide a forum for interaction among geologists and botanists, palynologists and paleobotanists, ecologists and paleoecologists. This book reflects very well the interdisciplinary approach to the different geobotanical problems.

R. L. STUCKEY and G. L. DENNY: *Prairie Fens and Bog Fens in Ohio: Floristic Similarities, Differences, and Geographical Affinities*.

In the present paper the investigated fens of Ohio are discussed from different points of view:

1. The distribution of fens in the state. A map of Ohio shows the locations of 52 fens investigated.

2. Successional stages of the fen meadow plant community. Three zones of the development were recognised as the most characteristic successional stages: (a) the open marl zone, (b) the sedge-meadow zone, (c) the shrub-meadow zone.

3. History of floristic studies.

4. Floristic similarities and differences. There are 30 common species of the 74 vascular plant species of the 52 fens. Twenty-four species more typically occur in the west-central fens which are referred to as *Prairie fens*, while 20 species mostly occur in northeastern, so-called *Bog fens*.

5. Geographical affinities and origin of the flora. Fifteen distribution maps of selected examples of species give a good illustration.

The authors call for the protection of these valuable fens which are very rich in glacial relict plants. The paper is a good, well-illustrated, summarizing work.

P. R. KREMER and W. SPACKMAN: *The Paleoecological Evidence for Environmental Changes in "Neopaleobotanical" Sediments of South Florida*.

This study presents the results of a complete paleoecological survey. Eleven tree island communities (hammocks) in Everglades of southern Florida were particularly analyzed with regard to their vegetation, petrology of subsurface peats and bedrock relationships.

By means of multilateral investigations of the modern vegetation as well as of fossil materials, the authors were able to give a paleoecological interpretation dating back nearly

5000 years B.P. Their work proved that peat petrology is an especially useful paleoecological and paleoenvironmental analytic tool. Several diagrams, good drawings and sectional profiles illustrated the paper well.

R. E. BAILEY and P. J. AHEARN: A Late- and Postglacial Pollen Record from Chippewa Bog, Lapeer Co., MI: Further Examination of White Pine and Beech Immigration into the Central Great Lakes Region.

In this interesting and excellent paper the vegetation history of Chippewa Bog is traced as far back as approximately 10 500 years B.P. with especial regard to the history of white pine and beech immigration. Up-to-date methods (computer cards, radiocarbon dates, etc.) were applied both in the field and in the laboratory. Pollen data are presented graphically in a percentage pollendiagram. The estimated time of arrival and the suggested immigration routes of *Pinus strobus* and *Fagus grandifolia* in the Great Lakes region are also mapped.

J. TERASMAE: Late-Wisconsin Deglaciation and Migration of Spruce into Southern Ontario, Canada.

The purpose of this good, complete work was to investigate the Late-Wisconsin history of vegetation (especially the spruce) related to the presence of mastodon and paleoindian occupations in southwestern Ontario with references to the current understanding of the deglaciation chronology.

During the last decade palynological studies of about ten lake sediment cores, paleobotanical data, and recent geological investigations of deglaciation have been done. The results are supported by about 50 radiocarbon dates. The pollen records extend to at least 13 000 years B.P. Good maps and diagrams help in understanding the Late Wisconsin geomorphological features, the glacial lake phases and lake level changes; the history of vegetation included the migration routes in southwestern Ontario, Lake Erie basin.

J. F. P. COTTER and G. H. CROWL: The Paleolimnology of Rose Lake, Potter Co., Pennsylvania: A Comparison of Palynologic and Paleo-pigment Studies.

Rose Lake situated in a kettle in north-central Pennsylvania is studied in the present paper.

Examination of biochemical fossils as chlorophyll derivatives, carotenoids and pollen-analyses were done. The studies of the sedimentary fossil pigments proved to be very valuable in the reconstruction of the paleoecology of lacustrine systems. This modern method can be used as a sensitive indicator of past and present trophic status, and to determine changes in the balance between autochthonous and allochthonous organic sediment contribution, the source of sedimentary organic matter and the presence or absence of open water conditions throughout the history of individual lakes.

Palynological evidence of a 13-meter core indicates a climate-induced vegetation succession from a spruce parkland to a pine forest, to a mixed hardwood forest in the surrounding region during the last $14\,175 \pm 100$ years.

The fossil sedimentary pigment data indicate that Rose Lake itself changed to a very small extent throughout its history, remaining oligotrophic from its inception.

Comparison of the pollen and pigment stratigraphies of Rose Lake indicates that the climate may not be the determining factor in changes in lake productivity. Other factors such as nutrient availability and changes in the circulation patterns of the lake appear to be dominant influences on lake productivity.

However, paleopigment studies in conjunction with palynologic studies provide information pertaining to the reconstruction of the history of lacustrine systems and surrounding regions.

An up-to-date, carefully done, comparative study has been presented in this paper.

W. J. MERRY: Pollen Study of Buried Tree Site Near Marquette Moraine.

A very interesting buried tree site was palynologically studied in this paper.

In 1976 pieces of spruce trees were uncovered in growth position, 20–30 feet below the surface, buried in silt and fine sand. A number of specimens had more than 150 annual rings and radiocarbon dates of outer wood averaged at about $10\,000 \pm 300$ years B.P.

Where the largest intact specimen was uncovered soil samples were taken for pollen analysis by the author in 1977. On the basis of these investigations glacial history of vegetation and climate are summarized in the present interesting paper, related to the history of the buried trees.

P. A. DELCOURT and H. R. DELCOURT: Vegetation Maps for Eastern North America: 40 000 Yr B.P. to the Present.

This work is a successful attempt on reconstruction of the paleovegetation of Eastern-North America from 40 000 years B.P. to the present. Seven (40 000, 25 000, 18 000, 14 000, 10 000, 5000, 200 yr B.P.) very clear paleovegetation maps were drawn on the basis of very abundant radiocarbon-dated pollen-stratigraphic evidence.

The paleovegetation maps emphasize that more than 60% of the last 40 000 years has been characterized by environmental conditions transitional between extreme glacial and non-glacial regimes.

These maps also are very good documentations of the major changes in distribution of Late-Quaternary vegetation types, along with the changing geography of ice-sheet margins, major preglacial and postglacial lakes and marine shorelines.

G. R. UPCHURCH, JR. and J. A. DOYLE: Paleocology of the Conifers *Frenelopsis* and *Pseudofrenelopsis* (*Cheirolepidiaceae*) from the Cretaceous Potomac Group of Maryland and Virginia.

A good paleobotanical work is published here on the paleocology of the Mesozoic Conifer family, *Cheirolepidiaceae*. Particular analysis of sedimentary, megafossil and palynological associations indicate that *Cheirolepidiaceae* were adapted to a wide range of habitats within the Mesozoic tropical and subtropical belts and cannot be used in isolation as indicators of coastal environments or marine influence. A very well documented and nicely illustrated paper has been presented.

W. H. BLACKWELL, D. M. BRANDENBURG and G. H. DUKES: The Structural and Phyto-geographic Affinities of Some Silicified Wood from the Mid-Tertiary of west-central Mississippi.

This paper contains the description, characterization and illustration of two types of fossil wood about which much confusion has existed. One wood proved to be gymnospermous (*Cupressinoxylon florense* sp. nov.), the other angiospermous (*Floroxylon variable* gen. and sp. nov.).

Evidence has proved that these silicified logs have tropical and not boreal characteristic as was thought earlier.

L. C. MATTEN and W. S. LACEY: Cupule Organization in Early Plants.

The present paper demonstrates several examples of different cupule organization in early seed plants from the Upper Devonian and Lower Carboniferous. Multiovulate cupule of nine species — included the oldest seeds — have been studied and reconstructed. A series of cross-sections of fossils are given.

Very important evolutionary questions are discussed in this nicely illustrated, good paper.

R. W. DEXTER: Plant Succession on a Filled Salt-marsh at Cape Ann, Massachusetts, 1958–1979.

Results of studies on the successional development of a filled salt-marsh are summarized in this paper.

The area has been observed each year for 21 years from the pioneer stage till when the sediment became revegetated to trace the successional development. The different stages are documented with very illustrative photographs.

Finally three abstracts of other interesting papers are presented in this book, very briefly:

A. H. KNOLL: The Environmental Distribution of Some Late Precambrian Microbial Assemblages.

J. A. DOYLE: Cretaceous Pollen and Early Angiosperm Evolution.

M. B. DAVIS: Mid-Holocene Hemlock Decline: Evidence for a Pathogen or Insect Outbreak.

The most important information is given by J. A. DOYLE in his excellent paper.

M. JÁRAI-KOMLÓDI

FRITSCHEN L. F.—GAY L. W.: Environmental Instrumentation. Springer Verlag New York—Heidelberg—Berlin 1979, pp. 216

During the past decade increased interest has been shown in the impact of environmental factors on living creatures. Moreover, handbooks published earlier on this subject, as for example the Meteorological Instruments by Middleton and Spilhaus, are either out-of-date or not available in the bookshops.

Publication of the current volume of the series "Springer Advanced Texts in Life Science" (D. REICHLÉ, series editor) is therefore most timely.

The nine chapters of the book can be divided into three main parts. Two chapters are concerned with the bases of measuring and the physical rudiments with an emphasis on the importance of the errors in measuring and estimation. The log-derivative method and probable

error analysis are described in detail by them, with the obtained error values being compared by way of two factual examples. The three measuring systems used most widely (SI, cgs and the English basic units of measure) are given in a separate table.

After the physical bases have been summed up, first the theory of the heat transmission processes, thus heat conduction, convection, heat-radiation; and, in connection with them, the most important concepts (evaporation, irradiation, emission, etc.) and laws (PLANCK's law, STEFAN-BOLTZMANN's law) are described. To understand the operation of the two basic measuring instruments, the WHEATSTON-bridge and the potentiometer, it is necessary to know the parallel, series and forked circuits.

In the six chapters of the second part the meteorological effects most important for living creatures are discussed at length.

The instruments to measure temperature are divided into six groups in the book (gas thermometer, liquid in glass, liquid in metal, bimetal, electric and sonic thermometers). Of these thermoelements and resistance thermometers are described in great detail. After the discussion of SEEBECK-, PELTIER- and THOMPSON's effects and the thermoelectric laws, the relation between electric force and temperature can be studied in five tables. In three of these tables the values of the heat-electromotive force are given for using thermoelements of different types. Not only the drawings of the basic thermoelement circuits, the different heat-element columns, control switches with heat element but also the thermistors are given. The description of the comparison of the heat-sensors of different type is very useful.

The authors point out the necessity of taking the errors of the heat elements and measuring instruments into consideration and of analysing in detail the occurring sources of errors.

A separate chapter is devoted to the problems of the convection of soil-heat which is not always taken into consideration by the experts studying the effects of the environmental factors, as its order of magnitude is often small and the daily and annual sums are normally next to zero. In autumn or spring or in a dry state of the soil, however, the daily convection of the soil-heat can reach considerable values which should be kept in mind. The conduction and radiometric methods of calibration of the instruments measuring convection are described briefly by the authors.

The description of the rudiments is followed by three methods of radiation measurement and by that of the radiation sensing resistors, heat-element columns, distillometers. Although this chapter is only of average extent, here the most detailed and best illustrated information on the measuring instruments to be used can be found; more than 20 radiation measuring instruments are described by the authors. A list of pyrheliometers suitable for measuring direct radiation, pyranometers measuring global solar radiation, pyrgeometers for measuring long-wave radiation as well as total hemispheric radiometers with their most important parameters, demands of their placement and calibration instructions.

In the chapter dealing with humidity and precipitation, tables are included over 25 pages after the concepts of absolute and specific humidity, saturation, lack of saturation, dew point, etc. have been determined. In a part of the tables the values of the saturation vapour pressure are given between -50°C and $\pm 102^{\circ}\text{C}$, with 0.1°C gradient. But in most of the tables the data needed for the application of the Assmann-psychrometer are summarized. Besides the classical Assmann-psychrometer, six hygrometers operating on different principles (electric absorption, ion-changing, infra-red, hair ones, etc.) are discussed by the authors.

Besides the cup and propeller anemometers the sonic phase-meter and the Doppler-anemometer, as well as the anemometers with thermometers are presented.

The importance of measuring the wind direction which is often disregarded, is emphasized and electric anemoscopes of four kinds are shown.

The shortest chapter (only nine pages) of the book includes information in connection with atmospheric pressure, the description of the liquid manometer, mercurial and aneroid barometers and correctional tables.

The last part includes aspects of collecting, converting and conveying the data and the systems of processing the digital data. In this part the sampling theorem worked out by Shannon, external noises influencing the actually measured data and the inner (electric) noises of the system processing the data as well as the methods for reducing the noise effects are described in detail.

To sum it up, it can be stated that the handbook is a work planned and written with great care. All the chapters of the book are followed by a description of the physical bases of the operation of the measuring instruments. The author's effort to call the readers' attention to the fact that the sources of error have a slight influence on the results of measurements and to the ways of eliminating or reducing them is particularly worth of noting.

I can recommend this book to all those who are interested in the interactions which may take place between living creatures and meteorological factors. Ecologists, agronomists, forest engineers dealing with the effect of environmental factors, as well as university students studying biology can benefit most from this publication.

M. NAGY

SAN PIETRO, A. (ed.): *Biosaline Research: A Look to the Future*. Environmental Science Research Vol. 23. Plenum Press, New York 1982, pp. 578

Biosaline research is a newly developed section of ecology. Among the various efforts to find renewable new sources of food and fuel for mankind, this is one of the most promising focussing the immense latent biopotential of arid lands, coastlines, brackish and saline waters.

The main purpose of this new trend is to establish a harmonious ecological and economical interplay of high solar radiation, high temperature, saline or brackish water availability and bioproduction of economically useful plants.

The geographical scope of these investigations covers the majority of the surface of the Earth: all marine water bodies, coastlands, inland brackish waters, saline lakes, all deserts and semiarid areas belong here.

The potential for increased future exploitation of these resources for food, fibre, energy and fine chemicals production, utilizing marine organisms, marine-adapted plants, and arid and semi-arid plants, is almost infinite provided the necessary technology becomes available through basic research.

This volume contains 57 papers, the whole material of the IInd International Workshop on Biosaline Research held in La Paz, Mexico, from 16–20 November, 1980. More than 100 participants mainly from Mexico, USA, Brazil, Israel, India, etc. took part in the Workshop.

The book falls into six sections:

1. The regional reviews were focussed on current biosaline research in various parts of the world and underscored the international scope of the overall endeavour. One may find reports of biosaline research of USA, Canada, Latin America, some European countries, Israel, East Asia, New Zealand, China, Japan, Saudi Arabia, etc. For each of the other topics, one or more acknowledged experts presented an up-to-date assessment of the "State of Science"; their own research, as well as that of the other investigators, as the first paper of each section.

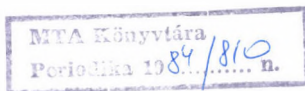
2. Section 2 "Food and Economic Plants" gives an insight into the present and future possibilities of growing agricultural and industrial plants (tomato, barley, wheat, potato, sweet corn, pepper, rice, many salt-tolerant grasses and weeds, etc.) in saline environment. Basically there have been two approaches to the development of crops which might be grown using highly saline water. One of these proposes to select and improve salt-tolerant wild plants to meet the food needs of man or domesticated animals. The other proposes to select for salt tolerance among conventional crops or to introduce such germplasm from wild sources by breeding and selection. The goal is common: to provide new options for agricultural production using presently unused, or underutilized resources. At this juncture it seems prudent to pursue vigorously both approaches.

3. Section 3 deals with the "Potential uses of micro- and macroalgae". The limits of the earth's arable lands, the continuing need for agricultural products and raw materials for industry, for animal feed and human food, the growth of world population, the increasing cost and depletion of fossil fuels all point to the need for new resources of agricultural products that will not tax the earth's declining agricultural and energy resources. Micro- and macroalgae may be very useful, significant and economical supplemental sources for these ends. The growth of algae does not make demands on land, mineral sources, energy supply in contrast with the conventional agricultural techniques.

Furthermore, the growth of microalgae in high rate domestic waste sewage oxidation ponds can provide valuable biomass and clean, useful water at the same time. Microalgae can be grown in saline or alkaline waters, in the tropical or subtropical arid lands, at relatively high temperature (up to 45 °C); conditions that are not useful for conventional agriculture.

In terms of photosynthetic efficiency, the microalgae are about the same level but in biomass productivity give much higher values than the traditional crops.

There are many existing practices of use of micro- and macroalgae as human or animal food and sources for important chemicals (ethanol, glycerol, vitamins), but there are far



more ready for use. These unexploited possibilities are at the treshold profitability. It may be that the next increase in oil prices will make them suddenly economical.

4. "Stress biology" section deals mainly with the physiological, biochemical and genetical aspects of salt tolerance of lower and higher plants. To understand these internal mechanisms at more depth we have — at least — two reasons: *a*) prevention of damage caused by salinity in the soil or irrigation water, and *b*) provide a scientific basis for breeding salt-tolerant new varieties of traditional crops.

Some of the current topics of the section are: biochemical response to salinity stress, osmoregulation and ion-transport of living cells in highly saline waters, use of brackish water in closed system agriculture, selected breeding lines of salt-tolerant hybrids of tomato.

5. "Present and future application" gives an account on different possibilities of industrial use of thermophilic and/or halophilic enzymes (mostly from bacteria) in biocatalytic conversions, possible use of marine organisms' extracts in anticancer chemotherapy, importance and restoration of coastline and estuaries mangrove forests, macroalgal mariculture ("marine farming") and waste removal by bacterial-algal-grass communities.

6. The last section contains 26 contributed papers on diverse topics: vegetative propagation of Jojoba shrub, microalgae as lipid source for industrial use, salt tolerance of wheat, cotton and barley; irrigation with seawater, etc.

All chapters are followed by bibliographies. The volume is supplied with subject index and a list of participants.

This well-documented book will be, very likely, welcomed by every ecologist who is interested in the possible and promising solutions of our common efforts to find reasonable alternatives for the presently used ecological sources and to explore new rich ones for the future.

Z. Szőcs

TRACEY, J. G.: *The Vegetation of the Humid Tropical Region of North Queensland*. CSIRO, Melbourne 1982, pp. 124, with 15 plates and 44 figures

This is one of the recently published monographs describing the very rich rainforest vegetation of Australia. Its importance and actuality is emphasized if we consider the urgent world-wide problem of tropical deforestation. Australia is no exception, its rainforests have already been eliminated through timber, mining and sugarcane exploitation, and only relatively small fragments remain along the east coast. The author's aim is to provide a possibly full description of the largest continuous area of rainforests in this continent. This work may serve as a framework for future use in forestry, agriculture, management of national parks and land use planning.

First, the author gives a brief account of the climatic and geographic conditions of the area. Emphasis is of course on the description of vegetation types that are characterized in relation to structure, habitat, present-day occurrence and floristic composition. Typification is mainly based on previously published work, numerical techniques are purposely not used. Profile diagrams and transects help reader to understand the structural similarities and differences among types. Vegetation mosaic maps and excellent black and white photographs provide further information. Data of sample sites and the species present are listed in an extensive Appendix.

This publication is certainly a great achievement. Regarding its low price this monograph is strongly recommended to anyone interested in tropical ecology and forestry.

J. PODANI

Preliminary Announcement

XIV. INTERNATIONAL BOTANICAL CONGRESS

Under the auspices of the International Union of Biological Sciences

Berlin (West), Germany, 24th July to 1st August 1987

The **Programme** will comprise 6 Division: metabolic botany, developmental botany, genetics and plant breeding, structural botany, systematic and evolutionary botany, and environmental botany. All plant groups will be considered, and aspects of both pure and applied research will be covered. Special emphasis will be laid on inter- and multidisciplinary topics. There will be plenary sessions, symposia, and sessions for submitted contributions (posters).

The **Nomenclature Section** will convene in Berlin on 20th to 24th July 1987. Pre- and post-congress scientific **Field Trips** will be arranged to various parts of Central, South and North Europe.

The **First Circular**, containing further details and a preliminary registration form, is now available. Send your name and full address to ensure your inclusion on the mailing list. Your early reply will be appreciated.

Chairman of the Organizing Committee: Prof. Dr. Dr. h.c. K. Esser.

Enquiries should be sent to the Secretary of the Organizing Committee, Prof. Dr. W. Greuter.

Congress Address: XIV IBC, Bot. Garden & Museum, Königin-Luise-Str. 6-8, D-1000 Berlin (West) 33, Germany.

ACTA BIOLOGICA

ACADEMIAE SCIENTIARUM HUNGARICAE

EDITOR
J. SALÁNKI

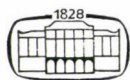
Volume 33

Number 4

CONTENTS

- Flemming, K.—Nothdurft, W.*: Investigations on the biphasic response of the reticuloendothelial system induced by the lipopolysaccharide of *Salmonella abortus equi* (pyrexal)
- Stoklosowa, S.*: Tissue culture of gonadal cells
- Csaba, G.—Ubornyák, L.*: Effect of polypeptide hormones (insulin, thyrotropin, gonadotropin, adrenocorticotropin) on RNA synthesis in *Tetrahymena*, as assessed from incorporation of ^3H -uridine
- Sohár, L.—Takács, Ö.—Guba, F.—Sziklai, L.—Szilágyi, T.*: Experimental studies on hypokinesia of skeletal muscle with different functions. VI
- E. Takács, I.—Szabó, J.—Szentmiklósi, A. J.—Szegei, J.*: The effect of hypothyroidism on myocardial contractility and sarcoplasmic reticulum function in rats
- Szeszák, F.*: Protein phosphatase activity in cell nuclei of rat liver and its relationship to the protein phosphatase in the cytoplasm
- Németh-Csóka, M.—Sárközi, A.*: The effect of proteoglycans of cartilage and oversulphated polysaccharides on the development of calcium-hydroxy-apatite (CHA) crystal formation *in vitro*
- Paschin, Yu. V.—Toropzev, S. N.*: Chromosome damage induced *in vivo* by heavy metal ion detected by indirect testing
- Csaba, G.—Ubornyák, L.*: Effect of plant hormones (IAA, NAA and TAA) on the ^3H -uridine incorporation of *Tetrahymena*
- Csaba, G.—Németh, G.—Vargha, P.*: Receptor memory in the unicellular *Tetrahymena*. Impact of treatment with analogous hormones
-

Papers in English. Published in one volume (4 issues) annually. Subscription rate per volume: \$40.00



AKADÉMAI KIADÓ

Publishing House of the Hungarian Academy of Sciences
Budapest

Distributed by KULTURA, Hungarian Foreign Trade Co., P. O. B. 149, H-1389 Budapest

ACTA ZOOLOGICA

ACADEMIAE SCIENTIARUM HUNGARICAE

REDIGIT
J. BALOGH

TOMUS XXVIII

FASCICULI 3–4

CONTENTS

- Andrássy, I.*: The Genera and Species of the Family Tylenchidae Örley, 1880 (Nematoda).
The Genus *Coslenchus* Siddiqi, 1978
- Kaszap, Z.*: Revision der australischen *Uloma*-Arten (Coleoptera: Tenebrionidae)
- Mahunka, S.*: Oribatids from the Eastern Part of the Ethiopian Region (Acari). I
- Móczár, L.*: Three New *Sulcomesitius* Species from Sri Lanka (Hymenoptera: Bethyridae)
- Papp, L.*: A New Apterous *Sphaerocerid* from Japan (Diptera: Sphaeroceridae)
- Pobozsny, M.*: On the Feeding Biology of Larval St. Mark's Fly, *Bibio marci* L. (Diptera: Bibionidae)
- Steinmann, H.*: A Revision of the Genus *Timomenus* Burr, 1907 (Dermaptera: Forficulidae)
- Szelényi, G.*: Further Data to the Torymid, Pteromalid and Eulophid Fauna of the Hortobágy National Park (Hymenoptera: Chalcidoidea)
- Vásárhelyi, T.*: A Study of the Relation of *Mezira tremulae* Germ. and Two Allied Species (Heteroptera: Aradidae)
- Vojnits, A. M.*: New *Eupithecia* Species from the Asiatic Regions of the Soviet Union and Iran
- Zicsi, A.*: Verzeichnis der bis 1971 beschriebenen und revidierten Taxa der Familie Lumbricidae (Oligochaeta)
- Zombori, L.*: The European Genera of Tenthredininae (Hymenoptera: Symphyta: Tenthredinidae)

Papers in English and German. Published in one volume (4 issues) annually. Subscription rate per volume: \$40.00



AKADÉMIAI KIADÓ

Publishing House of the Hungarian Academy of Sciences
Budapest

Distributed by KULTURA, Hungarian Foreign Trading Co., P.O.B. 149, H-1389 Budapest

PRINTED IN HUNGARY

Akadémiai Kiadó és Nyomda, Budapest

MAGYAR
TUDOMÁNYOS AKADÉMIA
KÖNYVTÁRA

The papers generally have the following components, which should be presented in the order listed:

1. Title, name of the author(s), affiliation, dateline, abstract, keywords
2. Text, acknowledgements
3. References
4. Footnotes
5. Tables
6. Figure captions
7. Illustrations

1. The *affiliation* should be as concise as possible and should include the complete mailing address of the authors. The date of receipt of the manuscript will be supplied by the editors. The abstract should be in English and should not exceed 250 words. It should clearly and simply summarize the most important methods and results. 5–10 significant expressions describing the content are used as keywords. Authors may recommend these keywords.

2. The *text* of the papers should be of high stylistic standard, requiring minor corrections only. The section headings, names of authors cited, latin names and terms should *not* be underlined or in capitals. Quantities should be expressed in SI-units.

3. *References* are accepted only in the Harvard system. Citation in the text must be as:
... (Jakucs 1961) ... or Jakucs (1961) ...
... (Fekete and Précsényi 1981) ...
... (Borhidi et al. 1979a) ...

The list of references should contain the names and initials of all authors (the abbreviation et al. is not accepted here); for *journal articles* year of publication, the title of the paper, title of the journal abbreviated, volume number, first and last pages.

For *books or chapters in books*, the title is followed by the publisher and place of publication. Book title words should be written with majuscules. Titles of papers published only in Hungarian should be translated in parentheses. All items are recommended to be cited both in the text and references.

Examples:

Jakucs, P. 1961: Die Phytozöologischen Verhältnisse der Flaumeichen-Buschwälder Südostmitteleuropas. Akadémiai Kiadó, Budapest.

Fekete, G., Précsényi, I. 1981: Niche structure of a perennial sandy grassland. In: Stefanovits, P., Berczik, Á., Fekete, G., Seidl, M. (eds): Man and the Biosphere Programme. Survey of 10 Years Activity in Hungary. Budapest, 68–102.

Borhidi, A., Muñiz, O., Del Risco, E. 1979a: Clasificación fitocenológica de la vegetación de Cuba. Acta Bot. Hung. 25: 263–301.

Jakucs, P. 1973: „Síkfőkút Projekt”. Egy tölgyes ökoszisztéma környezetbiológiai kutatása a bioszféra program keretein belül. (Síkfőkút-Project. Environmental-biological research of an oakwood ecosystem within the framework of the Biosphere program). MTA Biol. Oszt. Közl. 16: 11–25.

4. *Footnotes* should be typed on a separate sheet.

5. *Tables* should be typed on separate pages. They should be numbered serially with arabic numerals and have a concise heading each. Vertical lines are not used. Clear wording of column heads is advisable.

6. *Figure captions* should be provided on a separate sheet.

7. *Illustrations* must not be inserted in the text. Figures will be redrawn. Therefore the most important point is the clearness of the figures, even pencil drawings are accepted (with a duplicate). Photographs should be sharp and well contrasted. All the illustrations should bear the figure number and author's name in pencil on the reverse.

*

The editors will send information to the first author about the arrival and *acceptance* of the paper. Two *proofs* will be provided, which are requested to be returned within 48 hours of receipt to the editor. Alterations in the text and especially in the illustrations are expensive and should be avoided. Hundred *offprints* are supplied free of charge.

These instructions are valid as from 1983.

Periodicals of the Hungarian Academy of Sciences are obtainable
at the following addresses:

AUSTRALIA

C.B.D. LIBRARY AND SUBSCRIPTION SERVICE

Box 4886, G.P.O., *Sydney N.S.W. 2001*
COSMOS BOOKSHOP, 145 Ackland Street
St. Kilda (Melbourne), Victoria 3182

AUSTRIA

GLOBUS, Höchstädtplatz 3, *1206 Wien XX*

BELGIUM

OFFICE INTERNATIONAL DE LIBRAIRIE

30 Avenue Marnix, *1050 Bruxelles*
LIBRAIRIE DU MONDE ENTIER
162 rue du Midi, *1000 Bruxelles*

BULGARIA

HEMUS, Bulvar Ruszki 6, *Sofia*

CANADA

PANNONIA BOOKS, P.O. Box 1017
Postal Station "B", *Toronto, Ontario M5T 2T8*

CHINA

CNPICOR, Periodical Department, P.O. Box 50
Peking

CZECHOSLOVAKIA

MAD'ARSKÁ KULTURA, Národní třída 22
115 66 Praha
PNS DOVOZ TISKU, Vinohradská 46, *Praha 2*
PNS DOVOZ TLAČE, *Bratislava 2*

DENMARK

EJNAR MUNKSGAARD, Nørregade 6
1165 Copenhagen K

FEDERAL REPUBLIC OF GERMANY

KUNST UND WISSEN ERICH BIEBER
Postfach 46, *7000 Stuttgart 1*

FINLAND

AKATEEMINEN KIRJAKAUPPA, P.O. Box 128
SF-00101 Helsinki 10

FRANCE

DAWSON-FRANCE S. A., B. P. 40, *91121 Palaiseau*
EUROPÉRIODIQUES S. A., 31 Avenue de Versailles,
78170 La Celle St. Cloud
OFFICE INTERNATIONAL DE DOCUMENTATION
ET LIBRAIRIE, 48 rue Gay-Lussac
75240 Paris Cedex 05

GERMAN DEMOCRATIC REPUBLIC

HAUS DER UNGARISCHEN KULTUR
Karl Liebknecht-Straße 9, *DDR-102 Berlin*
DEUTSCHE POST ZEITUNGSVERTRIEBSAMT
Straße der Pariser Kommüne 3-4, *DDR-104 Berlin*

GREAT BRITAIN

BLACKWELL'S PERIODICALS DIVISION
Hythe Bridge Street, *Oxford OX1 2ET*
BUMPUS, HALDANE AND MAXWELL LTD.
Cowper Works, *Olney, Bucks MK46 4BN*
COLLET'S HOLDINGS LTD., Denington Estate
Wellingborough, Northants NN8 2QT
WM. DAWSON AND SONS LTD., Cannon House
Folkstone, Kent CT19 5EE
H. K. LEWIS AND CO., 136 Gower Street
London WC1E 6BS

GREECE

KOSTARAKIS BROTHERS INTERNATIONAL
BOOKSELLERS, 2 Hippokratous Street, *Athens-143*

HOLLAND

MEULENHOF-BRUNA B.V., Beulingstraat 2,
Amsterdam
MARTINUS NIJHOFF B.V.
Lange Voorhout 9-11, *Den Haag*

SWETS SUBSCRIPTION SERVICE

347b Heereweg, *Lisse*

INDIA

ALLIED PUBLISHING PRIVATE LTD., 13/14
Asaf Ali Road, *New Delhi 110001*
150 B-6 Mount Road, *Madras 600002*
INTERNATIONAL BOOK HOUSE PVT. LTD.
Madame Cama Road, *Bombay 400039*
THE STATE TRADING CORPORATION OF
INDIA LTD., Books Import Division, Chandralok
36 Janpath, *New Delhi 110001*

ITALY

INTERSCIENTIA, Via Mazzé 28, *10149 Torino*
LIBRERIA COMMISSIONARIA SANSONI, Via
Lamarmora 45, *50121 Firenze*
SANTO VANASIA, Via M. Macchi 58
20124 Milano
D. E. A., Via Lima 28, *00198 Roma*

JAPAN

KINOKUNIYA BOOK-STORE CO. LTD.
17-7 Shinjuku 3 chome, Shinjuku-ku, *Tokyo 160-91*
MARUZEN COMPANY LTD., Book Department,
P.O. Box 5050 Tokyo International, *Tokyo 100-31*
NAUKA LTD. IMPORT DEPARTMENT
2-30-19 Minami Ikebukuro, Toshima-ku, *Tokyo 171*

KOREA

CHULPANMUL, *Phenjan*

NORWAY

TANUM-TIDSKRIFT-SENTRALEN A.S., Karl
Johansgaten 41-43, *1000 Oslo*

POLAND

WĘGIERSKI INSTYTUT KULTURY, Marszał-
kowska 80, *00-517 Warszawa*
CKP I W, ul. Towarowa 23, *00-958 Warszawa*

ROUMANIA

D. E. P., *București*
ILEXIM, Calea Grivitei 64-66, *București*

SOVIET UNION

SOJUZPECHAT — IMPORT, *Moscow*
and the post offices in each town
MEZHDUNARODNAYA KNIGA, *Moscow G-200*

SPAIN

DIAZ DE SANTOS, Lagasca 95, *Madrid 6*

SWEDEN

ALMQVIST AND WIKSELL, Gamla Brogatan 26
101 20 Stockholm
GUMPERTS UNIVERSITETSBOKHANDEL AB
Box 346, *401 25 Göteborg 1*

SWITZERLAND

KARGER LIBRI AG, Petersgraben 31, *4011 Basel*

USA

EBSCO SUBSCRIPTION SERVICES
P.O. Box 1943, *Birmingham, Alabama 35201*
F. W. FAXON COMPANY, INC.
15 Southwest Park, *Westwood Mass. 02090*
THE MOORE-COTTRELL SUBSCRIPTION
AGENCIES, North Cohocton, *N. Y. 14868*
READ-MORE PUBLICATIONS, INC.
140 Cedar Street, *New York, N. Y. 10006*
STECHELT-MACMILLAN, INC.
7250 Westfield Avenue, *Pennsauken N. J. 08110*

YUGOSLAVIA

JUGOSLOVENSKA KNJIGA, Terazije 27, *Beograd*
FORUM, Vojvode Mišića 1, *21000 Novi Sad*